Essays on Cross-border Banking and Macroprudential Policy

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Essays on cross-border banking and macroprudential policy.

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"To mitigate potential negative cross-border spillovers, national and European [macroprudential] authorities must work together to assess ex ante the effects of planned actions at the level of the institution, the country, the region and the Union as a whole. Authorities should strive to minimise potential negative cross-border spillovers and to communicate coherently and in unison."

Mario Draghi, Chair of the ESRB
ESRB introductory statement, Brussels, 16 January 2012.

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Contents

General Introduction

The aim of this thesis is to evaluate the conduct of macroprudential policies in an heterogeneous monetary union, such as the Eurozone, by borrowing on the recent theoretical and empirical developments of Dynamic Stochastic General Equilibrium (DSGE) models.

This introduction briefly sketches the main building blocks of this thesis. Section 1 quickly summarizes the consequences of the recent financial crisis on the conduct of economic policy in developed economies, by insisting more particularly on the introduction of macroprudential concerns. Section 2 outlines some useful recent theoretical and econometric progresses made by DSGE models to account for financial factors in the determination of economic equilibrium and to provide the basis for the modeling of macroprudential policies. Section 3 presents some main Eurozone economic and institutional specificities that we consider to be important in the building of our analytical framework. Section 4 provides a survey of the main contributions of the thesis to the existing literature. Section 5 describes the structure of the thesis, organized in 5 chapters.

1 Towards a New Normality in Economic Policy

Over the two decades preceding the subprime crisis of 2007, a widespread consensus identified low and stable inflation as the primary mandate of monetary policy to provide macroeconomic stability. The general agreement among macroeconomists was that the decline in the variability of output and inflation ("the great moderation") observed in the data could be linked to a coherent policy framework based upon the conduct of monetary policy using an interest rate aimed at stabilizing inflation. Controlling inflation would in turn limit the output gap. In the meanwhile, mainstream macroeconomics had taken a benign view on financial factors in amplifying output and employment fluctuations. In this policy environment, the stability of the financial system was achieved through microprudential regulation insuring the soundness and safety of individual financial institutions.

Ignoring the macroeconomic implications of financial imbalances that affected the Eurozone (Figure 1) proved to be extremely costly. The consequences of the US sub-prime crisis of 2007 and the accompanying dramatic fall in output (Figure 2) and rise in unemployment exposed the limitations of the economic framework that was successful in providing macroeconomic stability during the "great moderation" period.

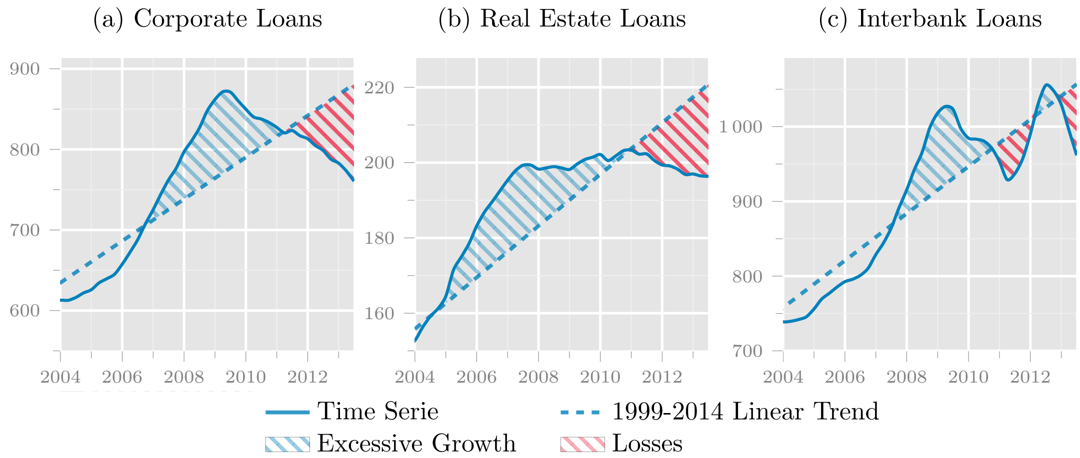


FIGURE 1: Boom and bust cycles in the Eurozone (*millions of euro per capita, sources ECB*).

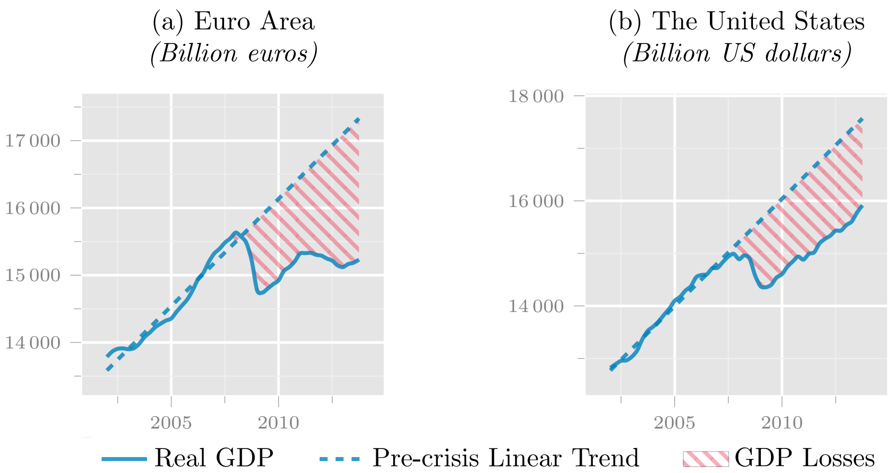


FIGURE 2: GDP Loss after the financial crisis episode in the Eurozone and the US (*Sources FRED*).

The financial crisis has accelerated the introduction of a new policy domain called macroprudential policy in developed countries, inspired by the early contributions of Crockett (2000). This episode has highlighted the need to go beyond a purely microeconomic approach to financial regulation and supervision. It has broken a general agreement limiting financial supervision at the microeconomic level, while a new consensus has emerged, considering that prudential measures should also be set at the aggregate level through macroprudential measures to complete monetary policy measures.

As broadly defined by the International Monetary Fund (IMF), the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments, so as to avoid periods of widespread distress. The novel dimension introduced by macroprudential policy is to promote the stability of the financial system in a global sense, not just focusing on individual financial intermediaries. This aggregate approach aims at solving a fallacy of composition in the evaluation of financial distress. A simple example makes this fallacy easy to understand: it is rational for a bank to sell assets with a decreasing value to mitigate the risk at the individual level. However, generalizing this decision at the aggregate level is not optimal for the economy as a whole since it leads to a higher decrease in the price of this asset, thus amplifying financial troubles. The definition of macroprudential measures is necessary to avoid this kind of problem.

Furthermore, as underlined by the IMF, the legislation regarding national macroprudential systems should include adequate provisions regarding the objective, the functions and the powers of the macroprudential authorities. Namely, clear objectives with explicit targets should guide the decision-making process and enhance the accountability of authorities. The key macroprudential functions should include the identification of systemic risks, the formulation of the appropriate policy response and the implementation of the policy response through adequate rulemaking. Finally, the macroprudential authority should be empowered to issue regulations, collect information, supervise regulated entities and enforce compliance with applicable rules.

Today, there is a main difference between monetary policy and macroprudential policy. There is a clear-cut consensus on the role of different instruments in the conduct of monetary policy, as the policy rate is seen as the primary instrument, while non-conventional tools should be used in situations where policy rates are close to the zero bound. In contrast, the literature on macroprudential policy is still far from such a consensus. Two aspects are currently debated on the conduct of macroprudential policy regarding the choice of instruments on the one hand, and the choice of an optimal institutional framework on the other hand.

In a series of papers, the IMF has tried to summarize existing macroprudential practices. Lim (2011) finds that up to 34 types of instruments are used. These instruments aimed at mitigating the building of financial imbalances can be classified along alternative criteria. As proposed by Blanchard et al. (2013), we can distinguish measures that are oriented towards lenders from those focusing on borrowers. Furthermore, a second typology distinguishes cross-sectional measures (*i.e.*, how risk is distributed at a point in time within the financial system) and tools addressing the time-series dimension of financial stability (coming from the procyclicality in the financial system). However in practice, this policy appears to be rather flexible, as different instruments can be used at the same time, depending on the national situation.

Regarding the way the macroprudential mandate should be implemented, the current debate focuses on the nature of the authority. The main question is to determine whether the macroprudential mandate should be given to an independent authority or whether it should be set by the central bank in line with monetary policy decisions.

The main argument in favor of mixing both monetary and macroprudential policies is the following: to the extent that macroprudential policy reduces systemic risks and creates buffers, it helps the task of monetary policy in the face of adverse financial shocks. It can reduce the risk that monetary policy runs into constraints in the face of adverse financial shocks, such as the zero lower bound. This can help alleviate conflicts in the pursuit of monetary policy and reduce the burden on monetary policy to "lean against" adverse financial developments, thereby creating greater room for the monetary authority to achieve price stability.

The main argument against this organization of the macroprudential mandate lies in the potential conflict of interest, or at least trade-offs, between the two policies. A monetary policy that is too loose may amplify the financial cycle or, conversely, a macroprudential policy that is too restrictive may have detrimental effects on credit provision and hence on monetary policy transmission. Where low policy rates are consistent with low inflation, they may still contribute to excessive credit growth and to the build-up of asset bubbles and induce financial instability.

As for the choice of the macroprudential instrument, different institutional solutions have been adopted in practice: in some cases, they involve a reconsideration of the institutional boundaries between central banks and financial regulatory agencies (or the creation of dedicated policymaking committees) while in other cases efforts are made to favor the cooperation of authorities within the existing institutional structure (Nier, 2011).

2 The Recent Evolution of DSGE Models

On the theoretical side, the financial crisis has deeply affected the structure of macroeconomic models. Before the financial crisis, DSGE models with nominal rigidities provided the intellectual foundation for the analysis of monetary policy questions. This class of models encompasses a variety of frameworks that ranges from the simple real business cycles model of Kydland & Prescott (1982), to the new classical growth model of King et al. (1988) or to the New Keynesian model of Smets & Wouters (2003). All these models are solved under a common assumption where agents solve intertemporal maximization problems under rational expectations. This assumption is deemed necessary to fix the anomalies of the old Keynesian macroeconomic theory. Before the existence of DSGE models, policy makers used to evaluate macroeconomic policy and perform forecasting exercises through old Keynesian models derived from a dynamic version of IS-LM model. These models did a good job in fitting and explaining Western economies until the stagflation period of the 1970s. Large oil-price shocks led both inflation and unemployment to rise. The standard approach of the Keynesian Phillips curve was unable to explain both high inflation and high unemployment at the same time. The trade-off between inflation and unemployment disappeared, leading policy makers to abandon Keynesian economics for a new theory able to explain both inflation and unemployment at the same time. It became clear that policy relevant models would require both expectations and micro-foundations to address inflation and unemployment problems.

Although DSGE models encompass a very wide class of frameworks, their development and popularity can be closely linked to monetary policy discussions during the “great moderation” period. The building of what has now become a benchmark framework for policy discussions can be traced back to Kydland & Prescott (1982). Their model describes a frictionless economy populated by households and firms, whose optimal responses to productivity shocks were able to replicate the key business cycles second moments for the US economy. However this model was not yet relevant for policy analysis as real frictions, monetary policy and data fitting were the main missing ingredients. Calvo (1983) was able to fill partially this gap by finding the micro-foundation of price stickiness in a utility-maximizing framework with rational expectations[1]. Taylor (1993) indirectly contributed to the improvement of DSGE models by finding empirically the policy rule which approximated well how a central bank decides its main interest rate. The so-called ”Taylor rule” was the missing equation which closed seminal sticky price models such as Goodfriend & King (1997) and Clarida et al. (1999).

The financial crisis of 2007, by outlining the key role of financial factors in shaping macroeconomic fluctuations, triggered an urgent need for a framework that could address financial stability issues. This episode led to a renewed interest in the analysis provided before the crisis by the contribution of Bernanke et al. (1999) linking financial distress to the financial accelerator. They showed that, with asymmetric information in capital markets, the balance sheet of borrowers may play a role in business cycles through their impact on the cost of external finance. This model was good at replicating the dynamic

[1] In the same vein, Rotemberg (1982) developed a similar sticky price model with a different micro-foundation.

of capital markets in the US where markets play a larger role in transactions between providers and users of capital.

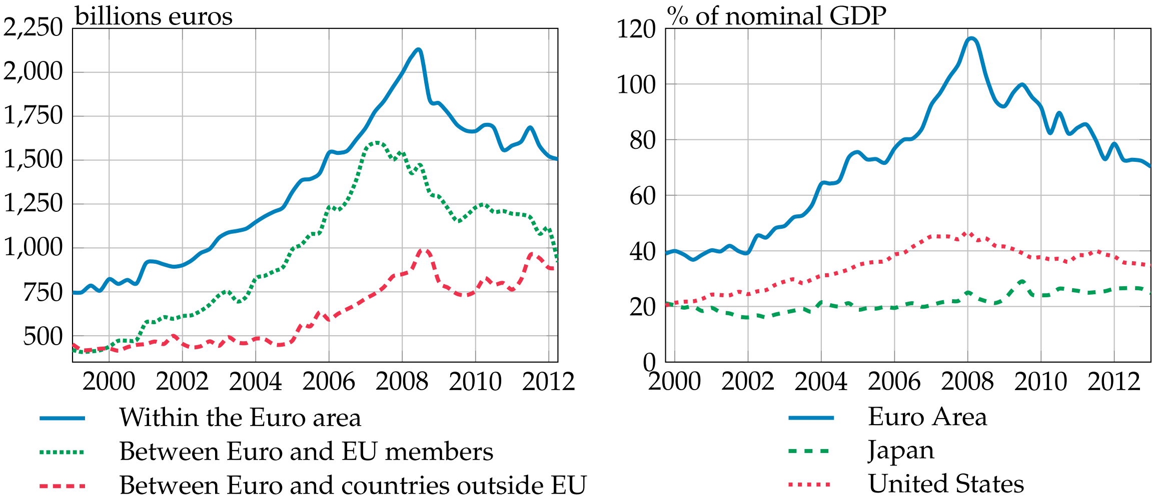
Up to recently, a critical aspect of DSGE modeling was the emphasis on theoretical analysis and the lack of application (namely the fact that policy experiments were based on calibration rather than on the estimation of structural parameters). Recent progress exemplified by Christiano et al. (2005) and Smets & Wouters (2003, 2007) solved this problem by extending the Bayesian econometrics to the estimation of DSGE models. This approach provides a complete quantitative description of the joint stochastic processes by which a set of aggregate variables evolve, and provides a direct comparison of the simulated series with the relevant observed time series. As a consequence, DSGE models are quickly emerging as a useful tool for quantitative policy analysis in macroeconomics and variants of the Smets-Wouters model are used by most central banks. Furthermore, DSGE models provide an interesting toolkit for deriving the optimal value of the macroprudential stance and for performing welfare and counterfactual analyses to rank alternative macroprudential implementation schemes.

3 European Features

The aim of this thesis is to study how macroprudential policy should be conducted in an heterogenous monetary union such as the EMU using new developments in DSGE models. We more particularly adapt existing DSGE models to account for the main economic and institutional particularities of this area.

On the economic ground, we account for two main stylized facts related to the banking system that make a key difference with models developed to analyze US developments. First, the role of the banking system is much more important in the Eurozone than in the United States. Unlike the US, capital market funding to the European economy is mediated via the banks. This implies a different framework to address external financing in the Eurosystem: in 2012 the size of the banking sector in the European Union was 4.5 times larger than its US counterpart (respectively 347% of EU GDP and 74% of US GDP).

Second, the adoption of the euro has foster cross-border banking between the participating countries. By eliminating currency risk, the adoption of the euro in 1999 generated forces for a greater economic and financial integration. The single currency reshaped financial markets and international investment patterns by enhancing cross-border banking activity between the members of the European Monetary Union (EMU). This phenomenon can be measured along various complementary dimensions such as the increase of FDI in bank activities, the diversification of bank assets and liabilities between countries, the access of local banks to international financial sources or through the increase of banks' lending via foreign branches and direct cross-border lending.



(a) Cross-border loans of MFIs residing in the euro area

(b) Total Amount of Banks' Foreign Claims in % of nominal GDP

FIGURE 3: Globalization of banks balance sheet in Europe and abroad since 1999 (*Sources BIS*).

As underlined by Figure 3, cross-border lending is a distinguishing feature of financial integration in the Eurozone. Cross-border loans have been multiplied by three in nine years, before experiencing a 25% decrease after the recent financial crisis. The financial crisis stopped the financial integration through cross-border banking, and made business cycles to divergence between core and peripheral countries. At its peak value in 2008, total cross-border lending represented around 120% of GDP for Eurozone countries, while the corresponding figure was 40% for the US and 20% for Japan. However, concentrating on the composition of cross border lending underlines the heterogenous nature of this integration. As illustrated in Figure 4, this cross-border phenomenon affects mainly interbank lending and corporate lending, while cross-border lending to households is negligible.

On the institutional ground, in 2008, the European Commission tasked a High Level Group to consider different possibilities to provide economic stability in the Eurosystem. Among its many conclusions, De Larosière (2009) suggested the establishment of a new organization of financial supervision based on two pillars: the first pillar is devoted to macro-prudential supervision comprising the European Systemic Risk Board (ESRB) and a second pillar devoted to micro-prudential supervision comprises three different European Supervisory Authorities (ESAs) – one for banking, one for insurance and one for the securities markets.

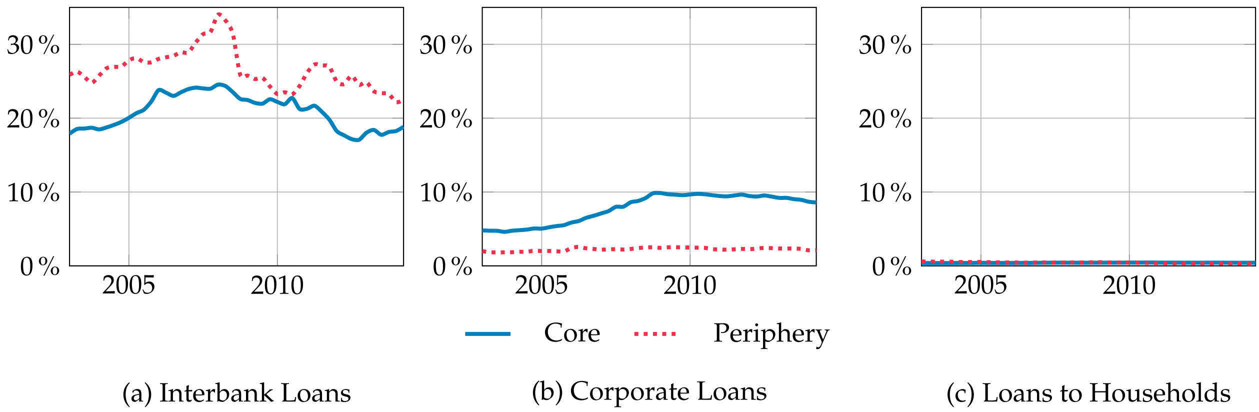


FIGURE 4: Share of cross-border loans (by loan type) between EMU participants in the assets of core and peripheral banks of the Eurosystem. (*Sources: ECB*)

One year later, the legislation establishing the ESRB entered into force to monitor and assess systemic risk in normal times for the purpose of failure of systemic components and improving the financial system resilience to shocks. Owing to the federal structure of the Eurozone, the institutional organization of this new policy is original with regards to other developed economies. As underlined by Loisel (2014), this group of countries has a single monetary authority (the European Central Bank), a common macroprudential authority (the European Systemic Risk Board) and national macroprudential authorities.

As an original founding principle of the ESRB, macroprudential policy is tailored to the situation of countries to fit the heterogeneity of national financial cycles. This heterogeneity is underlined in Figure 5 by contrasting Eurozone core and peripheral countries according to their status in terms of surplus or deficit of their current account[2]. As reported, main differences characterize financial developments in these two groups of countries. In particular, peripheral countries experienced an explosive growth of corporate loans followed by a sharp drop. These heterogenous financial developments between core and peripheral countries may, in turn, require alternative macroprudential measures.

The problem faced by the ESRB is to accommodate these heterogeneous national financial development with more homogenous national practices than encountered before the recent financial crisis. Different policy initiatives have been taken since the creation of the ESRB, and a road map has been set to enhance more homogenous practices among countries participating to this structure. As underlined by ESRB (2013, report October), this calendar can be analyzed as providing a smooth transition towards a

[2]Core countries: Austria, Belgium, Germany, Finland, France, Luxembourg and the Netherlands. Peripheral countries: Spain, Greece, Ireland, Italy and Portugal.

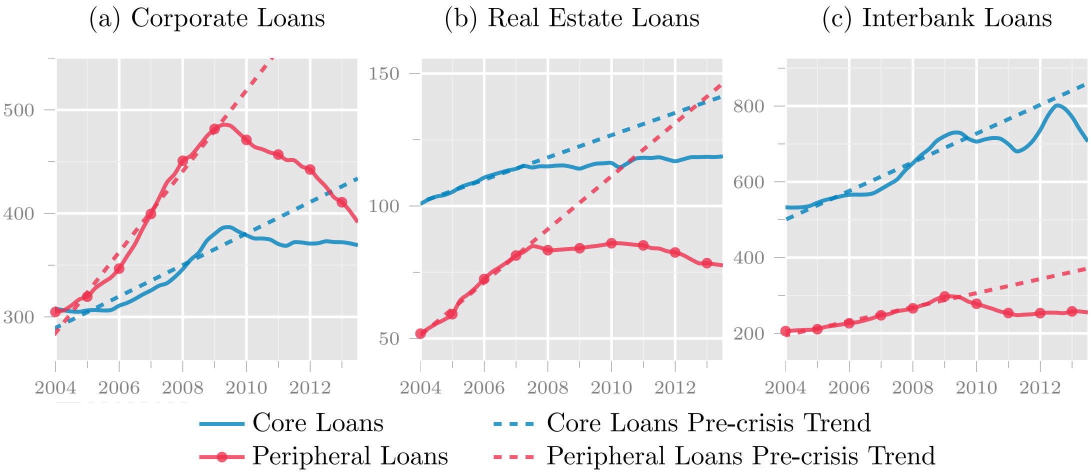


FIGURE 5: Structural divergences in the supply of loans before the financial crisis episode (*per capita million euro, sources Eurostats*)

more centralized and symmetric system. Heterogenous business and financial cycles developments between core and peripheral economies of the Eurozone make it difficult to implement uniform macroprudential decisions. As a simple illustration of the question at hands, Figure 6 reports the heterogeneity in the interest rate reaction of the central bank that should be required to accommodate regional discrepancies, according to two simple policy rules (a Taylor rule reacting to regional inflation and an extended rule that reacting to regional lending developments). As shown, accounting for regional financial differences makes the two interest rate reactions more heterogenous.

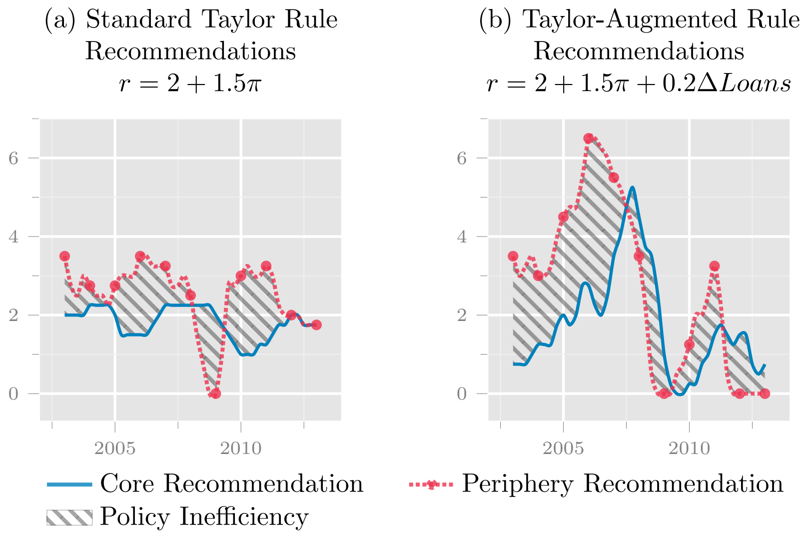


FIGURE 6: Regional divergences and their implications for the implementation of an homogenous macroprudential policy (*sources Eurostats*).

A key problem for macroprudential authorities is to account for spillovers coming from cross-border lending. On one hand the interest of keeping heterogeneous macroprudential policy measures allows a granular treatment of financial risk in the Eurozone: as macro-prudential policies can target specific sectors or regional developments, they may attenuate the credit cycle heterogeneity that characterizes the euro area and support a more balanced diffusion of monetary policy developments in the Eurozone. On the other hand, the move towards more symmetric practices in the conduct of macroprudential practices can be justified on an economic ground as countries belonging to the Eurozone constitute an integrated financial area. The transfer of macroprudential powers to the Federal level can thus make sense as cross-border banking activities have increased the interconnection of financial decisions in the Eurozone. As noted by Schoenmaker (2013), even if a centralized model should not imply a uniform application of the macroprudential tools across the countries in the Single Supervisory Mechanism (SSM), as the European Central Bank may wish to apply a uniform macro-prudential requirement when a particular asset is increasing too fast in many SSM countries.

4 Key Contributions of the Thesis

To analyze the conduct of macroprudential policy in an heterogenous monetary union such as the Eurozone, we use two country DSGE models estimated using Bayesian techniques.

The main analytical contributions can be listed as follows:

- *A new microfoundation of the financial accelerator* that allows a more tractable estimation of parameters in a two country world. Since the seminal contribution of Bernanke et al. (1999), the financial accelerator lies at the center of DSGE models with financial frictions on the capital market. However the estimation of this mechanism is challenging in two country open economy models. In our setting, we assume that the financial accelerator does not result from a moral hazard problem but rather from a bias in the expectations of the private sector *à la* De Grauwe (2010). This assumption simplifies the framework and allows us to extend and estimate the accelerator phenomenon in an international perspective. Finally, given the bank-based nature of finance in Europe, we reinterpret the financial accelerator from a banking perspective by introducing banks facing the default risk of borrowers.

- *A new way of modeling cross-border banking flows* between countries. The integration of the Euro area has been carried out by financial rather than by real factors. With our new microfounded financial accelerator, we are able to offer a tractable and simple introduction of cross-border lending in a real business cycle framework.

We use a CES aggregator that combines loans with different geographical origins and a home bias to sum up the total amount of loans contracted in each region. This modeling solution inspired by the New Open Economy Macroeconomics offers an simple way to account for international spillovers in credit cycles.

- *An interbank market with heterogenous banks in terms of liquidity.* This aspect is important when dealing with financial aspects in the Eurozone, owing to the size of the banking system. As observed in the data, cross border interbank lending is important between Eurozone members. In our modeling strategy, we assume that this phenomenon arises from the existence of illiquid banks that borrow from liquid banks, located either in their home economy or abroad. In our setting, we assume that banks are similar except in their access to ECB fundings. As a consequence, banks with excess liquidity lend to the banks that do not have access to this refinancing operations of the central bank. Following Goodfriend & McCallum (2007) and Cúrdia & Woodford (2010), we assume that the intermediation process is costly on the interbank market which implies that liquid banks have a monitoring technology when supplying loans.

- *A richer set of financial frictions* to match the business and credit cycles of an heterogenous monetary union. More particularly, we account for the imperfect transmission of monetary policy by assuming that credit and deposit rates are sticky via a Calvo-type technology on these variables. Following this modeling choice, we are able to catch up differences in the transmission of monetary policy between core and peripheral countries. Moreover, we assume that borrowing decisions are subject to external habits to catch up the inertia in the supply of interbank and corporate loans observed in the data.

- *A welfare analysis of macroprudential policies in an international perspective based on permanent consumption equivalent.* In our policy experiments, national authorities face the choice of cooperating or not to conduct macroprudential policy actions. Under this perspective, we analyze the cooperation/deviation choice problem as a bargaining game *à la* Nash. This approach allows us to underline possible conflicts between the global and the national levels in the monetary union.

- *an estimation of the parameters of the models using recent progresses in the Bayesian econometrics* adapted to DSGE models. This approach, that mainly follows the major contributions of Smets & Wouters (2003, 2007), allows us to quantify the welfare gains following the adoption of alternative macroprudential policies.

The main results obtained in this thesis can be summarized as follows:

- As a main result, *the implementation of macroprudential policy measures improves welfare at the federal level* with respect to the conduct of an optimal monetary policy. Depending on the macroprudential instrument selected, on the number of instruments and on the implementation scheme, welfare gains rank from 0.004% to a 0.902% increase in permanent consumption. The highest welfare gains are observed when countries use multiple instruments and when macroprudential policy is implemented in a granular fashion.

- However, *the conduct of macroprudential policy based on the maximization of the welfare of a representative Eurozone agent is not a free lunch for participating countries.* Our results show that in most situations peripheral countries are winners (in the best situation, the representative consumer of the peripheral region of the Eurozone gets a 3.443% increase in permanent consumption) while core countries record either smaller welfare gains or even welfare losses (in the worst situation, core countries' permanent consumption can decrease by 2.061%).

- *The heterogeneity of welfare results observed at the national levels questions the implementability of macroprudential schemes following national incentives.* In particular reaching the Pareto optimal equilibrium of the Eurozone may incur welfare losses for core countries. In many policy experiments, we find that there exists an equilibrium that combines welfare increases at both the global and national levels for all participants. this "sustainable" equilibrium is better than the Nash equilibrium. However, its enforceability requires a federal action, thus justifying the existence of a coordination mechanism such as the ESRB in the Eurozone.

- Finally our results underline the *critical role of cross border loans to assess the consequences of macroprudential policy measures in the Eurozone.* The possibility of banks to engage in cross border lending introduces an important spillover channel that tends to increase the welfare gains associated with macroprudential measures. Ignoring this phenomenon may lead to fallacious results in terms of the welfare ranking of alternative implementation schemes.

5 Structure of the Thesis

This thesis comprises 5 essays presented in 5 chapters.

Chapter 1, entitled "*An Introduction to Macroprudential Policy*", introduces the topic of macroprudential policy in a simplified setting. The aim of this chapter is to convey the basic ideas of what macroprudential policy is. We use a static version of the "3-equations New Keynesian Macroeconomics" model such as the one introduced by Bofinger et al. (2006) to avoid technical complexities arising from a full fledge DSGE model. To introduce the role of financial intermediaries in the determination of the macroeconomic equilibrium, we complete the core structure of the three-equation model witha financial friction in the *IS* curve to account for the fact that investment projects may be financed with loans.

We get three main results: First, we find that monetary policy cannot fulfill a dual mandate of price and financial stability as the macroeconomic outcome deteriorates in terms of inflation when monetary policy has a concern for financial stability. This illustrates the problem of a missing instrument to achieve a supplementary goal. Second, we find that a macroprudential policy succeeds at mitigating financial imbalances and appears as a natural solution to solve the Tinbergen problem. Finally, regarding the interaction between monetary and macroprudential policies, we find that a cooperative solution is better than a Nash solution in terms of social welfare to provide both price and financial stability.

Chapter 2, entitled "*Cross-border Corporate Loans and International Business Cycles in a Monetary Union*", introduces a first DSGE framework that can address both cross-border lending and financial heterogeneity between member countries of the Eurosystem. We extend the model of Smets & Wouters (2007) in a two country set-up with a banking sector, credit-constrained entrepreneurs and international corporate loan flows. This chapter examines the macroeconomic consequences of cross-border loans using a DSGE model of a monetary union estimated on German and French country data. To introduce cross-border banking, we assume that entrepreneurs can subscribe loans from home and foreign banks.

We get four main results: First, we find that cross-border corporate facilities significantly affect the international transmission of asymmetric shocks. Second, this cross-border channel has had more impact on France and has strengthened the dissemination of financial shocks between the two countries. Third, our model also reveals that under banking globalization, current account imbalances are more persistent than in banking autarky. Finally, the variations in the ECB's key rate became more sensitive to shocks at the expense of real shocks.

Chapter 3, entitled "*Macroprudential Policy with Cross-border Corporate Loans: Granularity Matters*", aims at measuring the welfare gains obtained through the granular implementation of macroprudential measures in the Eurozone. Using Bayesian techniques, we estimate the model of chapter 2 extended to an asymmetric two-country set-up that accounts for cross-border bank lending and diverging business cycles between core and peripheral countries[3] of the Euro Area.

We get three main results: First as in chapter 1, macroprudential policy and monetary policy should be kept separated in the EMU. Second, it is optimal to set macroprudential policy parameters at the regional level since this solution dominates the uniform setting of macroprudential parameters in terms of permanent consumption gains. Third we outline a possible conflict between the federal and national levels in the conduct of macroprudential policy in a monetary union. On the one hand, the Pareto optimum equilibrium requires a regional reaction to the union wide rate of loan growth. However, this situation implies a decrease in core country welfare with respect to an optimal monetary policy without macroprudential concerns. On the other hand, a granular solution reacting to the regional loan creation (*i.e.*, taking into account the financial sector rather than borrowers) with parameters set at the regional parameters leads to lower welfare gains at the federal level but implies regional welfare gains in the two parts of the monetary union.

Chapter 4, entitled "*Cross-border Interbank Loans and International Spillovers in a Monetary Union*", develops a model that fully accounts of the nature of cross border lending in the Eurozone, by combining interbank and corporate cross-border loan flows. We estimate the model in a similar way as in chapter 3 using a complete sample from ECB internal backcasted time series.

We get three main results: First, we find similar results than in chapter 2, which proves that our approach is robust to different specifications (in terms of monetary policy issues and current account disequilibrium). Second, we find that cross-border lending has contributed to a better mutualization of the negative consequences of the financial crisis over the region: it has amplified the fluctuations of all core countries' variables, while dampening that of peripheral countries. Finally, we find that the model fit is strongly improved with cross-border banking flows, suggesting that it is a key pattern of the business and credit cycles of the Eurosystem that should be included in the next generation of DSGE models for policy analysis.

Chapter 5, entitled "*Combining National Macroprudential Measures with Cross-border Interbank Loans in a Monetary Union*", aims at finding the best setting of multiple macroprudential tools in the Eurosystem given their possible cross-border spillovers. As in chapter 4, we account for both interbank and corporate cross-border loan flows. The model comprises two asymmetric regions in size and in terms of financial openness.

[3] In the sample, countries with current accounts surpluses belong to the core group while other countries are in the peripheral group.

Once the model is estimated using core/periphery data, we compute the welfare of the monetary union using a second order approximation to the policy function. In our policy experiments, national macroprudential authorities face a dual choice. First, they have the possibility to use alternative instruments to affect either the lending or borrowing conditions of their country. Second, they have the possibility to cooperate with other national macroprudential authorities. We analyze the cooperation choice problem as a bargaining game *"à la* Nash*"*.

We get three main results*:* First, as in chapter 3, we report a possible conflict between the federal and the national levels in the implementation of heterogenous macroprudential measures based on a single instrument. On federal ground, the Pareto optimal situation requires an asymmetric choice of instruments. However, this is a no free lunch situation as it may create regional welfare losses. On regional grounds, more symmetric practices should be preferred to provide welfare gains to all the participating countries. Second, the adoption of combined instruments in each country solves this potential conflict as it leads to both a higher welfare increase in the Pareto optimal equilibrium and always incurs national welfare gains. Third, the Pareto optimal equilibrium cannot be reached on national incentives. Thus a supranational enforcing mechanism such as the one introduced by the ESRB is necessary, independently of the nature and number of macroprudential instruments adopted in each country.

Chapter 1

An Introduction to Macroprudential Policy

1 Introduction

The financial turmoil of 2007 has significantly affected the landscape of short run macroeconomics. This episode has reassessed the amplifying role of financial factors in economic fluctuations. On the policy side, it has induced new practices in the conduct of monetary policy such as the adoption of unconventional measures. Furthermore, it has led economists to evaluate new policy practices regarding the way risks associated to financial decisions should be controlled to dampen output fluctuations. This episode has broken a general agreement limiting financial supervision at the micro level. A new consensus has emerged, considering that prudential measures should also be set at the aggregate level to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments.

As broadly defined by the International Monetary Fund (IMF), the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments, so as to avoid periods of widespread distress.

Macroprudential policy should now be treated as a specific topic in intermediate macroeconomics courses, as the implementation such measures is becoming a generalized practice of developed economies to prevent the building of financial imbalances. However, the literature available on this subject is generally not well suited to this teaching objective. Most of the published papers on this subject are either institutional (describing how such practices should be introduced in existing institutional set up) or devoted to theoretical aspects generally based on Dynamic Stochastic General Equilibrium (DSGE) modelling (for a survey, see for example Galati & Moessner (2013)).

The aim of this chapter is to convey the basic ideas of what macroprudential policy is. Its objective is to bridge the gap between recent theoretical progress made by DSGE models regarding the way macroprudential measures should be conducted and a more standard model used to teach short run macroeconomics as encountered in undergraduate textbooks. We provide a simple and compact presentation of the main elements that could be introduced in an intermediate macroeconomics course to account for the impact of financial factors on the determination of macroeconomic equilibrium and for the development of policy measures designed to dampen the consequences of financial imbalances. We more particularly discuss three related questions: (*i*) the consequences of financial frictions on the transmission of shocks; (*ii*) the debate regarding the introduction of financial stability concerns in the setting of the interest rate set by the central bank; (*iii*) the consequences of macroprudential measures and the optimal institutional design of the macroprudential mandate in relation with the conduct of the monetary policy.

This chapter develops a static framework in line with some recent papers recently published to present the new developments of monetary policy practices to intermediate level students. This chapter should thus be considered as a possible complement to Walsh (2002) (that presents the main features of inflation targeting in a pre crisis environment), Bofinger et al. (2006) (that present both a compact way of introducing the 3-equation New Keynesian Model and that introduce the students to the debate between simple and optimal monetary rules), Friedman (2013) (that discusses the way unconventional monetary policy measures should be conducted in a New Keynesian Model following the financial crisis), Buttet & Roy (2014) (that offer a simple treatment of the question of conduct of monetary policy at the zero lower bound) and Woodford (2010) (that presents the way financial intermediation should be integrated into macroeconomic analysis and how it should be taken into account for the conduct of monetary policy).

In this chapter, we use a static version of the “3-equations New Keynesian Macroeconomics” model such as the one introduced by Bofinger et al. (2006). A static framework helps to concentrate on the key aspects of the question: it allows the simple use of undergraduate concepts (such as the IS or AD schedules or the computation of Nash and cooperative equilibria), while neglecting technical complexities arising from a full fledged DSGE model. To introduce the role of financial intermediaries in the determination of the macroeconomic equilibrium, we complete the core structure of the three-equation model on two aspects. First, as in Woodford (2010), we introduce a financial friction in the IS curve to account for the fact that investment projects may be financed with loans. Second, we develop the description of the banking system to provide a fourth equation that explains the determination of the interest rate for private sector loans. This relation provides a simple channel to account for the procyclicality of financial factors and the possibility to conduct preventive macroprudential measures.

To get a clear understanding of the question at hand, we focus on three main "gaps": the output gap (*i.e.*, the difference between actual and full employment output), the inflation gap (*i.e.*, the difference between the actual and the targeted inflation rate) and the interest rate spread (*i.e.*, the difference between the interest rate on bank loans and the interest rate of the central bank). All along the chapter, we evaluate the consequences of the different policy settings on these three main indicators, to help the student understanding the way alternative policy decisions affect the macroeconomic equilibrium.

To introduce macroprudential policy, we proceed in three steps. First, assuming that monetary authorities follow a simple interest rate rule, we evaluate the consequences of taking into account the working of the banking system in shaping the transmission of supply and demand shocks. Second, we discuss the possibility to extend monetary policy to follow financial stability objectives, assuming that the central bank implements an optimal monetary policy. In this situation we outline the cost of this policy in terms of price stability so that, the introduction of macroprudential measures can be useful to solve a problem of missing instrument (Tinbergen 1952). Third, we discuss the nature of macroprudential policy, accounting for the fact that this is a debated question regarding both the choice of instruments and the way such decisions should be taken in relation with the conduct of monetary policy[1]. To provide a clear analysis of the challenging aspects of this policy we analyze a situation where the macroprudential instrument is the capital requirement of the banking sector by contrasting a situation where the macroprudential authorities are different from the central bank (Nash equilibrium) and a situation where a common agency manages the two policy instruments (cooperative equilibrium).

The rest of the chapter is organized as follows: Section 2 introduces the model and evaluates how financial frictions amplify demand and supply shocks. Section 3 extends the discussion to the case of an optimal monetary policy and discusses whether monetary policy should account for financial stress as an additional objective. Section 4 introduces macroprudential policy in a simplified way to discussed how such a policy should be set

[1]The two main institutionnal questions related to this subject that should be presented to the student (the choice of an macroprudential instrument and the relation between macroprudentail decisions and monetary policy decisions) are briefly sketched to set the way such institutionnal aspects should be taken in consideration to present the main features of this policy.

in line with monetary policy. Section 5 concludes with a summary of the main elements of the chapter and some developments of the analysis.

2 The effect of financial frictions in the case of a simple monetary policy rule

This first section extends a static version of the three-equations new Keynesian macroeconomics to take into account the role of the banking system in the determination of the macroeconomic equilibrium. We complete existing models such as Bofinger et al. (2006) with a fourth equation that describes the financial accelerator related to lending conditions. To underline the key role of lending decisions in shaping output developments, it is useful to provide students with a simple representation such as Figure 1.1.

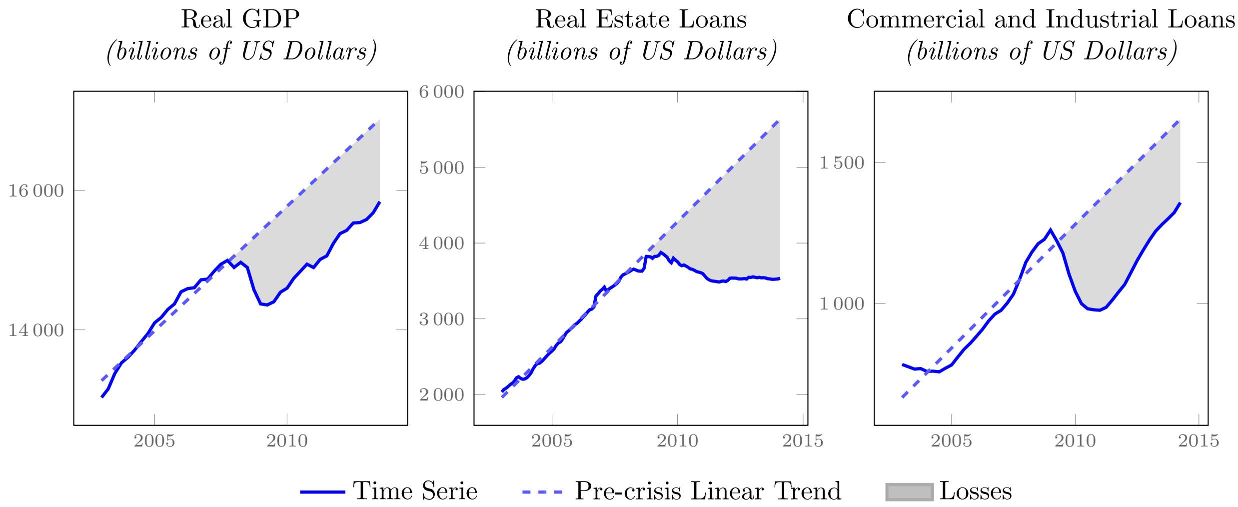


FIGURE 1.1: Output and loan costs after the 2007 financial crisis episode for the US economy.
Sources: FRED database.

As observed, the financial developments of credit in the US economy move in line with activity. In particular during the recent financial crisis, it is easy to see how the credit crunch is in line with contraction of US output. The first step of the discussion presented to students should thus be to understand the procyclicality of financial decisions and the consequences of this phenomenon in the transmission of demand and supply shocks.

2.1 A Static New Keynesian Model with a Banking System

We build a static new Keynesian model that accounts for a banking system. The core elements of the model (namely, a Phillips curve, an IS curve and a Taylor rule) are affected by financial frictions: we assume that investment projects require loans from the banking system. As underlined by Woodford (2010) in actual economies, we observe different interest rates that do not co-move perfectly. In real life situations, savers find intermediaries who use these funds to lend to ultimate borrowers. Thus borrowers are faced with an interest rate that differs from the interest rate set by monetary authorities. In what follows, we distinguish two interest rates in the economy. The interest rate relevant to conduct monetary policy decisions corresponds to the one used in the refinancing procedure conducted by most central banks. The interest rate relevant for private decisions corresponds to the one used for financing decisions of longer maturity.

This modification in the benchmark model affects directly the structure of the IS curve. The IS curve accounts for a nominal rate relevant to private sector spending decisions that is different from the policy oriented interest rate used by the central bank. This modelling feature is in line with Bernanke & Gertler (1989), Cecchetti & Li (2008), Cecchetti & Kohler (2012) and Friedman (2013). The benchmark model is:

$$PC : \hat{\pi} = \pi_0 + \sigma_y \hat{y} + \hat{\epsilon}_S, \tag{1.1}$$

$$IS : \hat{y} = -\alpha_r (\hat{r} - r_n) - \alpha_\rho \hat{\rho} + \hat{\epsilon}_D, \tag{1.2}$$

$$MP : \hat{r} = r_n + \phi^y \hat{y} + \phi^\pi (\hat{\pi} - \pi_0). \tag{1.3}$$

In this model, $\hat{\pi}$ is the rate of inflation, $\hat{y}$ is the output gap, $\hat{r}$ is the policy relevant interest rate and $\hat{\rho}$ is the nominal lending rate relevant to private sector funding decisions. To get a simple static expression for all equations, we assume that monetary policy is credible (inflation expectations are based on the targeted inflation rate, π_0). Parameter σ_y is the elasticity of inflation to the output gap, $-\alpha_r$ is the elasticity of the output gap to the policy oriented interest rate, r_n is natural interest rate (so that in the absence of shocks and financial frictions the output gap is zero and $r = r_n$), $-\alpha_\rho$ is the elasticity of the output gap to the interest rate on bank loans. Regarding monetary policy (MP), ϕ^y is the elasticity of the interest rate to the output gap and $\phi^\pi \geq 1$ is the elasticity of the interest rate to the inflation rate. Finally $\hat{\epsilon}_S$ is a cost-push shock on the supply side (a positive realization of this shock describes an exogenous increase in goods prices) and $\hat{\epsilon}_D$ is a demand shock.

This 3-equation model must be completed by the banking system to provide a relation that determines the private sector rate of interest $\hat{\rho}$. We borrow from Cecchetti & Li (2008) the following description of the determination of the interest rate from the equilibrium of the loan market. First, the amount of loans supplied by the banking system ($\hat{L}^S$) depends on bank capital ($\hat{B}$) and on the net amount of deposits ($\hat{D}$) over the amount needed in terms of reserves:

$$\hat{L}^S = \hat{B} + \tau\hat{D},$$
$$\hat{B} = b\hat{y},$$
$$\hat{D} = \delta_y\hat{y} - \delta_r\hat{r},$$

where τ is equal to one minus the rate of bank reserves. We assume that bank capital positively reacts to the output gap, where b is the sensitivity of bank capital to the output gap. As underlined by Woodford (2010), an increase in activity boosts the value of the banks' assets as loans are more likely to be repaid. This, in turn, allows a larger volume of credit distribution for any given interest rate spread. Following Cecchetti & Kohler (2012), deposits are positively related to the output gap (with sensitivity δ_y) and negatively to the policy rate (with sensitivity $-\delta_r$). Second, the level of loan demand from households and firms (L^D) is positively related to the output gap (with sensitivity l_y) and is negatively related to the lending rate (with sensitivity $-l_\rho$):

$$\hat{L}^D = l_y\hat{y} - l_\rho\hat{\rho}.$$

After imposing the credit market clearing condition ($L^S = L^D$), the value of the lending rate ρ that solves this equilibrium condition writes:

$$\hat{\rho} = -\theta_y y + \theta_k\hat{r}.$$

This relation introduces two financial channels that affect the way supply and demand shocks are transmitted to the macroeconomic equilibrium. The first parameter $\theta_y = \left[(b + \tau\delta_y) - l_y\right]/l_\rho$ measures the elasticity of the interest rate to output gap, while the second parameter $\theta_k = \tau\delta_r/l_\rho$ accounts for the imperfect interest rate pass-through. These two parameters summarize the way the decisions of the banking system affect the macroeconomic equilibrium, both through the diffusion of supply and demand shocks and through the transmission of monetary policy decisions to the rest of the economy.

The first elasticity θ_y accounts for the procyclicality of the financial system if $(b + \tau\delta_y) > l_y$. In an economy where loan supply is more reactive than loan demand to the fluctuations in the output gap (namely, $b + \tau\delta_y > l_y$), an increase in the output gap leads to a reduction in the value of the interest rate[2]. The second elasticity θ_k relies to the diffusion of monetary policy decisions to stabilize the economy. The value of this parameter

[2]This phenomenon can be traced to the various distortions inherent in financial relationships stemming from the existence of asymmetric information between banks and borrowers. In this setting an increase in the output gap improves the collateral of borrower and lead banks to decrease lending rate. By so intermediaries may give rise to excessive risk-taking: there can be an endogenous build-up of imbalances within the financial system that, in the case of an adverse event, could generate a systemic event.

depends on a ratio between the interest rate elasticity of loan supply ($\tau\delta_r$) and the elasticity of loan demand (l_ρ). The imperfect transmission of monetary policy decisions on the loan interest rate constitutes a second financial friction in the economy, as it creates some uncertainty on the final impact of central bank decisions on the macroeconomic equilibrium. When loan demand is more reactive than loan supply to the fluctuations of the central bank policy rate, commercial banks may increase their margin by dampening the decrease of the interest rate.

In this chapter, we concentrate on the first distortion, namely the procyclicality of financial decisions, by assuming a complete interest rate pass through (*i.e.*, $\theta_k = 1$)[3] while we set $\theta_y > 1$. This restriction is useful as it leads to a simple expression of the financial accelerator (FA) as in Bernanke et al. (1999):

$$FA : \hat{\rho} - \hat{r} = -\theta_y \hat{y}. \tag{1.4}$$

According to this relation, the external finance premium $\rho - r$ is countercyclical as a positive output gap reduces the interest rate spread. The financial accelerator operates as follows: a positive output gap by relaxing the interest rate spread leads to more investment decisions, that in turn implies a further increase in the output gap.

2.2 The Consequences of the Procyclicality of the Financial System

The model (1.1)-(1.4) can be solved sequentially to evaluate the effect of financial frictions on key relations such as the IS and AD curves. First, combining the IS curve with the equilibrium condition on the loan market with $\theta_k = 1$, we get the financially constrained IS-FA relation:

$$IS\text{-}FA : \hat{y} = \frac{\alpha_r r_n}{(1-\alpha_\rho\theta_y)} - \frac{(\alpha_r + \alpha_\rho)}{(1-\alpha_\rho\theta_y)}\hat{r} + \frac{1}{(1-\alpha_\rho\theta_y)}\hat{\epsilon}_D. \tag{1.5}$$

The standard expression of the IS schedule is obtained when disabling credit frictions $\alpha_\rho = 0$. Financial frictions affect both the slope of the IS curve and the impact of demand shocks on the situation of this schedule in the (y, r) space. Second combining the constrained IS-FA curve (1.2) with the Taylor rule (1.3), we get the Aggregate

[3] In this simplified setting, keeping a unitary interest rate pass-through leads to the divine coincidence as presented by Bofinger et al. (2006). This situation simplifies the computation of the results in this model. An imperfect interest rate pass-through would affect the transmission of monetary policy decisions on the economy. By so, it will have consequences under an optimal monetary policy as it suppresses the divine coincidence and reintroduces the impact of demand shocks on activity and on inflation. Although this question matters in real life situations, it is only secondary for the question at hand in this chapter.

Demand schedule that accounts for the Banking system (ADB) as:

$$ADB : \hat{y} = \frac{\alpha_r r_n + \hat{\epsilon}_D - (\alpha_r + \alpha_\rho)\left[r_n + \phi^\pi (\hat{\pi} - \pi_0)\right]}{(1 - \alpha_\rho \theta_y) + (\alpha_r + \alpha_\rho)\,\phi^y}.$$

The standard expression of the Aggregate Demand (AD) schedule is obtained without financial frictions $\alpha_\rho = 0$. The equilibrium of the model determines the output gap y^* and the inflation rate π^* as a solution to the ADB-PC system:

$$\hat{y}^* = \frac{\alpha_r r_n + \hat{\epsilon}_D - (\alpha_r + \alpha_\rho)\left[r_n + \phi^\pi \hat{\epsilon}_S\right]}{(1 - \alpha_\rho \theta_y) + (\alpha_r + \alpha_\rho)\left(\phi^y + \phi^\pi \sigma_y\right)},$$

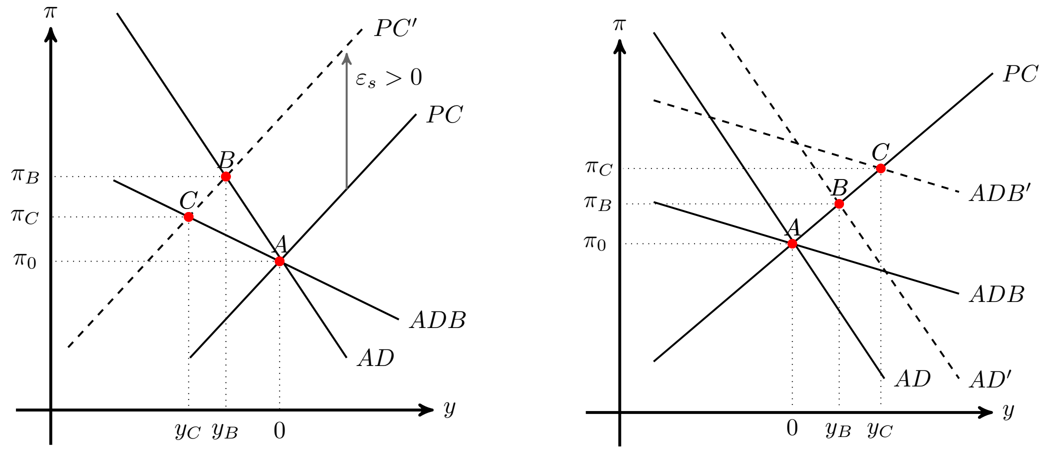
$$\hat{\pi} = \pi_0 + \frac{\sigma_y\left[\alpha_r r_n + \hat{\epsilon}_D - (\alpha_r + \alpha_\rho)\, r_n\right] + \left[(1 - \alpha_\rho \theta_y) + (\alpha_r + \alpha_\rho)\,\phi^y\right]\hat{\epsilon}_S}{(1 - \alpha_\rho \theta_y) + (\alpha_r + \alpha_\rho)\left[\phi^y + \sigma_y \phi^\pi\right]}.$$

The consequences of financial frictions on the diffusion of supply (ϵ_S) and demand (ϵ_D) shocks are reported in Table 1.1. As observed, in the case of high procyclicality of financial factors (namely when $\theta_y > \sigma_y + \phi^y$), supply and demand shocks amplify the variation of the output gap. In contrast, the inflationary consequences of the supply shocks are dampened with financial frictions.

	With financial frictions ($\theta_y > 0$)		Without financial frictions ($\theta_y = 0$)
$\partial \hat{y}^* / \partial \hat{\epsilon}_D$	$\left\lvert \frac{1}{(1-\alpha_\rho\theta_y)+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$	$>$	$\left\lvert \frac{1}{1+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$
$\partial \hat{y}^* / \partial \hat{\epsilon}_S$	$\left\lvert \frac{-(\alpha_r+\alpha_\rho)\phi^\pi}{(1-\alpha_\rho\theta_y)+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$	$>$	$\left\lvert \frac{-(\alpha_r+\alpha_\rho)\phi^\pi}{1+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$
$\partial \hat{\pi}^* / \partial \hat{\epsilon}_D$	$\left\lvert \frac{\sigma_y}{(1-\alpha_\rho\theta_y)+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$	$>$	$\left\lvert \frac{\sigma_y}{1+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$
$\partial \hat{\pi}^* / \partial \hat{\epsilon}_S$	$\left\lvert \frac{(1-\alpha_\rho\theta_y)+(\alpha_r+\alpha_\rho)\phi^y}{(1-\alpha_\rho\theta_y)+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$	$<$	$\left\lvert \frac{1+\alpha_r\phi^y}{1+(\alpha_r+\alpha_\rho)(\phi^y+\phi^\pi\sigma_y)} \right\rvert$

TABLE 1.1: Diffusion of supply and demand shocks with and without financial frictions.

To understand the results of Table 1.1, we illustrate graphically these two shocks in Figure 1.2a and Figure 1.2b. The standard model is depicted in the $(\hat{y}, \hat{\pi})$ space by the AD-PC schedules, while the model with the banking system is depicted by the ADB-PC schedules. To understand the destabilizing features of the procyclicality of lending, we assume that the procyclicality of the financial sector (summarized by θ_y) is higher than the countercyclical factors given by the $(\sigma_y + \phi^y)$ (the sum of the elasticity inflation with respect to the output gap in the Phillips curve and the elasticity of the policy interest rate to the output gap in the Taylor rule). With $\theta_y > \sigma_y + \phi^y$, the slope of the ADB curve is flatter than the standard AD curve.



(A) Positive cost push shock $\epsilon_S > 0$ (B) Positive demand shock $\epsilon_D > 0$

FIGURE 1.2: A comparison of supply and demand shocks effects with and without financial frictions

In figure 1.2a, a positive cost push shock ($\hat{\epsilon}_S > 0$) moves the PC schedule upwards. As a negative supply shock, it leads to a negative output gap and an increase in inflation. The procyclicality of financial factors amplifies the negative impact of the shock as this tends to increase the interest rate gap in the economy and, as a by-product, implies a higher decrease in the output gap as ($\hat{y}_C < \hat{y}_B$). In the meanwhile, as the procyclicality of financial factors reduces more aggregate demand in the economy, the cost-push shock leads to less inflation ($\hat{\pi}_B > \hat{\pi}_C$).

In figure 1.2b, a positive demand shock ($\hat{\epsilon}_D > 0$) moves the ADB schedule rightward further than the baseline AD curve, as $\theta_y > \phi^y$. For an unchanged PC schedule, this amplifies both the output and the inflation gaps. Indeed, the procyclicality of financial factors amplifies the positive impact of the shock as this tends to decrease the interest rate gap in the economy: By improving the solvability of borrowers, a higher output gap leads banks to decrease the interest rates on private loans. This implies a further increase in the output gap ($\hat{y}_C > \hat{y}_B$), which in turn has a higher impact on the inflation rate ($\hat{\pi}_C > \hat{\pi}_B$).

As illustrated by this simple model, a high procyclicality of the financial sector leads to higher fluctuations in the output gap and, by so, may require a specific reaction of the authorities over the standard policy of targeting inflation.

3 Optimal Monetary Policy and the Concern for Financial Stability

As the procyclicality of financial decisions amplifies the impact of shocks on the output gap, the natural question that arises is to determine whether monetary policy should react to the building of financial imbalances. This problem is analyzed in the context of the choice of an optimal monetary policy. As a main interest, this approach (discussed by Bofinger et al. (2006) in a static framework) computes the interest rate reaction to supply and demand shocks on the basis of the minimization of the country loss function. The sensitivity of the interest rate reaction to shocks is thus determined endogenously, depending on the objective(s) of monetary policy.

3.1 The Optimal Monetary Policy without a Financial Stability Concern

In the standard analysis of optimal monetary policy, such as the one proposed by Bofinger et al. (2006), the interest rate is chosen by the authorities to minimize a quadratic loss function ($\mathcal{L}$) expressed in terms of the output gap, y, and the inflation gap ($\hat{\pi} - \pi_0$):

$$\mathcal{L} = \frac{1}{2}\hat{y}^2 + \frac{\lambda_\pi}{2}(\hat{\pi} - \pi_0)^2, \tag{1.6}$$

subject to the supply constraint PC (equation (1.1)) of the private sector. In this expression, λ_π represents the weight imposed on inflation rate deviations with respect to the full employment target. The first order conditions that solve this problem can be combined to get the targeting rule as:

$$\hat{y}^{opt} = -\sigma_y \lambda_\pi (\hat{\pi}^{opt} - \pi_0). \tag{1.7}$$

This targeting rule defines the desired balance that the central bank wants to reach between full employment and price stabilization. It accounts for both society's inflation reluctance (λ_π) and the elasticity of the inflation rate to the output gap in the Phillips curve (σ_y). The marginal rate of substitution between inflation and the output gap (a sort of *"sacrifice ratio"*) is determined by:

$$\frac{\partial(\hat{\pi}^{opt} - \pi_0)}{-\partial y^{opt}} = \frac{1}{\sigma_y \lambda_\pi},$$

so the central bank accepts a higher increase in inflation ($\partial(\hat{\pi}^{opt} - \pi_0)$) following a 1% reduction in the output gap ($-\partial \hat{y}^{opt}$) when the weight associated to the objective of price stability is lower (λ_π) or for a lower elasticity of the inflation rate with respect to the output gap (σ_y). The solution of the optimal monetary policy[4] is summarized in Table 1.2. As observed, we get a new version of the *"divine coincidence"* that also applies to the interest rate differential[5]. Namely, acting optimally (*i.e.*, setting the best

[4]The solution procedure is as follows: combining the targeting rule with the Phillips curve we get a solution for either the output gap or the inflation gap; combining the solution for the output gap with the loan market equilibrium condition, we get the interest rate gap.

[5]An extensive presentation of this situation is proposed by Bofinger et al. (2006).

value for the interest rate), the monetary authorities are able to close the output gap following a demand shock. Acting so, they reach both the inflation target and there is no effect of the demand shock on the interest rate gap. To support this equilibrium monetary authorities must set their interest rate as:

$$\hat{r}^{opt} = \frac{(1-\alpha_\rho\theta_y)\lambda_\pi\sigma_y}{(\alpha_r+\alpha_\rho)\left(1+\lambda_\pi\sigma_y^2\right)}\hat{\epsilon}_S + \frac{1}{(\alpha_r+\alpha_\rho)}\hat{\epsilon}_D + \frac{\alpha_r r_n}{(\alpha_r+\alpha_\rho)}$$

3.2 The Optimal Monetary Policy with a Financial Stability Concern

In this framework, it is possible to account for the concern of financial stability by extending the authorities' loss function to the spread between the lending and the policy oriented interest rates, as proposed by Cecchetti & Kohler (2012):

$$\mathcal{L} = \frac{1}{2}\hat{y}^2 + \frac{\lambda_\pi}{2}(\hat{\pi}-\pi_0)^2 + \frac{\lambda_\rho}{2}(\hat{\rho}-\hat{r})^2.$$

In this expression, the relative weight regarding the inflation gap (λ_π) and the interest rate spread (λ_ρ) are expressed with respect to the full employment target. As the authorities are now making an arbitrage between three main concerns, they minimize this function subject to the Phillips curve PC (equation (1.1)) and the financial accelerator FA (equation (1.4)). Combining the three first order conditions that solve this minimization program, we now get a targeting rule that combines the three policy concerns as:

$$\hat{y}^{opt} = \lambda_\pi(\hat{\pi}^{opt}-\pi_0)\sigma_y + \lambda_\rho(\hat{\rho}^{opt}-\hat{r}^{opt})\theta_y.$$

Combining this expression with the Financial accelerator (FA), the marginal rate of substitution between inflation and the output gap is now given as:

$$\frac{\partial(\hat{\pi}^{opt}-\pi_0)}{-\partial\hat{y}^{opt}} = \frac{1+\theta_y^2\lambda_\rho}{\sigma_y\lambda_\pi} > \frac{1}{\sigma_y\gamma_1}.$$

If the central bank interest rate decision accounts for financial stability as well as price stability, it should accepts a higher increase in inflation following a 1% reduction in the output gap. Combining the targeting rule, the Phillips curve and the financial accelerator relation, we get the reduced form of the results as reported in the second column of Table 1.2.

Finally, using the IS curve to compute the interest rate needed to support this equilibrium, we get:

$$\hat{r}^{opt} = \frac{(1-\alpha_\rho\theta_y)\lambda_\pi\sigma_y}{(\alpha_r+\alpha_\rho)\left(1+\gamma_1\sigma_y^2+\lambda_\rho\theta_y^2\right)}\hat{\epsilon}_S + \frac{1}{(\alpha_r+\alpha_\rho)}\hat{\epsilon}_D + \frac{\alpha_r r_n}{(\alpha_r+\alpha_\rho)}.$$

	Standard Policy		Extended Policy with Financial Stability
$(\hat{\pi} - \pi_0)$	$\left\lvert \frac{1}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S \right\rvert$	$<$	$\left\lvert \frac{1+\theta_y^2\lambda_\rho}{1+\theta_y^2\gamma_2+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S \right\rvert$
$\hat{y}$	$\left\lvert \frac{-\sigma_y\lambda_\pi}{1+\sigma_y^2\gamma_1}\hat{\epsilon}_S \right\rvert$	$>$	$\left\lvert \frac{-\sigma_y\lambda_\pi}{1+\theta_y^2\lambda_\rho+\sigma_y^2\gamma_1}\hat{\epsilon}_S \right\rvert$
$(\hat{\rho} - \hat{r})$	$\left\lvert \frac{\theta_y\sigma_y\lambda_\pi}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S \right\rvert$	$>$	$\left\lvert \frac{\sigma_y\theta_y^2\lambda_\rho}{1+\theta_y^2\lambda_\rho+\sigma_y^2\gamma_1}\hat{\epsilon}_S \right\rvert$

TABLE 1.2: Model response to a cost push shock ϵ_S under optimal monetary policy with and without a financial concern.

The divine coincidence is still observed at the general equilibrium of the model: the authorities are able to close the output gap, the inflation and the interest rate spread following a demand shock. However, the picture is a bit different regarding the impact of a cost push shock. As observed, the introduction of financial stability concerns in the definition of an optimal monetary policy affects the macroeconomic outcome, as it clearly stabilizes both the output and interest rate gaps, while it deteriorates the inflation outcome. Indeed, contrasting the authorities' interest rate reaction in the two situations, we find that extending the mandate of monetary policy to stabilize the interest rate spread leads to a smaller increase in the interest rate in case of supply shocks. As monetary policy is less restrictive, inflation is higher while the interest rate spread is lower.

Targeting financial stability as a supplementary objective of monetary policy defined in terms of an optimal interest rate rule is sub-optimal in terms of price stability. This may illustrate the problem of a missing instrument to achieve a supplementary goal. As already underline by Tinbergen (1952), one further (linearly independent) policy target requires one further (linearly independent) instrument. Thus, macroprudential policy can be introduced as a simple solution to this missing instrument problem.

4 Macroprudential Policy

The management of financial stability as an supplementary concern of monetary policy is a debated question. By so, the introduction of an additional macroeconomic policy instrument aimed at mitigating financial imbalances appears as a natural solution to solve the Tinbergen problem outlined in the previous section. To introduce the main interest of this policy, we first provide the student with a quick survey of the two main debated questions regarding the choice of instruments and the relation with monetary policy. We then illustrate the terms of this debate in our model. We introduce macroprudential concerns using bank capital requirements as an instrument and analyze how such measures should be taken in conjunction with monetary policy decisions.

4.1 The Nature of Macroprudential Policy

As broadly defined by the International Monetary Fund (IMF), the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments, so as to avoid periods of widespread distress. The novel dimension introduced by macroprudential policy is to promote the stability of the financial system in a global sense, not just focusing on individual financial intermediaries. This aggregate approach aims at solving a fallacy of composition in the evaluation of financial distress. A simple example makes this fallacy easy to understand: it is rational for a bank to sell assets with a decreasing value to mitigate the risk at the individual level. However, generalizing this decision at the aggregate level is not optimal for the economy as a whole since it leads to a higher decrease in the price of this asset thus amplifying financial troubles. The definition of macroprudential measures is necessary to avoid this kind of problem.

Furthermore, as underlined by the IMF, the legislation regarding national macroprudential systems should include adequate provisions regarding the objective, the functions and the powers of the macroprudential authorities. Namely, clear objectives with explicit targets should guide the decision-making process and enhance the accountability of authorities. The key macroprudential functions should include the identification of systemic risks, the formulation of the appropriate policy response and the implementation of the policy response through adequate rulemaking. Finally, the macroprudential authority should be empowered to issue regulations, collect information, supervise regulated entities and enforce compliance with applicable rules.

Today, there is a main difference between monetary policy and macroprudential policy. There is a clear-cut consensus on the role of different instruments in the conduct of monetary policy, as the policy rate is seen as the primary instrument, while non-conventional tools should be used in situations where policy rates are close to the zero lower bound. In contrast, the literature on macroprudential policy is still far from such a consensus. Two aspects are currently debated on the conduct of macroprudential policy regarding the choice of instruments on the one hand, and the choice of an optimal institutional framework on the other hand.

In a series of papers, the IMF has tried to summarize existing macroprudential practices. Lim (2011) finds that up to 34 types of instruments are used. These instruments aimed at mitigating the building of financial imbalances can be classified along alternative criteria. As proposed by Blanchard et al. (2013), we can distinguish measures that are oriented towards lenders from those towards borrowers. Furthermore, a second typology distinguishes cross-sectional measures (*i.e.*, how risk is distributed at a point in time within the financial system) and tools geared towards addressing the time-series dimension of financial stability (coming from the procyclicality in the financial system). However in practice, this policy appears to be rather flexible, as different instruments can be used at the same time depending on the national situation.

Regarding the way the macroprudential mandate should be implemented, the current debate focuses on the nature of the authority. The main question is to determine whether the macroprudential mandate should be given to an independent authority or whether it should be set by the central bank in line with monetary policy decisions.

The main argument in favor of mixing both monetary and macroprudential policies is the following: to the extent that macroprudential policy reduces systemic risks and creates buffers, this helps the task of monetary policy in the face of adverse financial shocks. It can reduce the risk that monetary policy runs into constraints in the face of adverse financial shocks, such as the zero lower bound. This can help alleviate conflicts in the pursuit of monetary policy and reduce the burden on monetary policy to 'lean against' adverse financial developments, thereby creating greater room for the monetary authority to achieve price stability.

The main argument against this organization of the macroprudential mandate lies in the potential conflict of interest, or at least trade-offs, between the two policies. A monetary policy that is too loose may amplify the financial cycle or, conversely, a macroprudential policy that is too restrictive may have detrimental effects on credit provision and hence on monetary policy transmission. Where low policy rates are consistent with low inflation, they may still contribute to excessive credit growth and the build-up of asset bubbles and induce financial instability.

As for the choice of the macroprudential instrument, different solutions have been adopted in practice: in some cases, it involves a reconsideration of the institutional boundaries between central banks and financial regulatory agencies (or the creation of dedicated policymaking committees) while in other cases efforts are made to favor the cooperation of authorities within the existing institutional structure Nier (2011).

4.2 The Design of Macroprudential Policy

To provide the student with a simple approach to macroprudential issues, we follow Cecchetti & Kohler (2012), by assuming that the instrument set by the relevant authorities is related to bank capital requirements ($\hat{k}$). As previously underlined, the main problem stems from the procyclicality of financial decisions. This macroprudential instrument moderates the financial cycle, as it constrains the increase of loans in good times, while it dampens the reduction of loans in bad times. The aggregate supply of loans now writes[6]:

$$\hat{L}^S = \hat{B} - \varkappa \hat{k} + \tau \hat{D}.$$

where parameter $\varkappa$ measures the sensitivity of loans supplied by the consolidated banking system to capital requirements $\hat{k}$. Solving the equilibrium condition of the loan market ($\hat{L}^D = \hat{L}^S$) for the value of the lending rate $\hat{\rho}$, with a complete interest rate pass-through, this new instrument affects the financial accelerator (FA') as it drives a wedge between the interest rate spread ($\hat{\rho} - \hat{r}$) and the output gap (y):

$$FA' : \hat{\rho} - \hat{r} = -\theta_y \hat{y} + \theta_k \hat{k}. \tag{1.8}$$

In this expression, $\theta_k = \varkappa / l_\rho$ is the elasticity of the interest rate gap to the bank capital requirement: it is equal to the ratio between the sensitivity of the loan supply to this instrument and the elasticity of loan demand to the lending interest rate. In this situation, the authorities in charge of financial stability can control the interest rate spread with their own policy instrument, $\hat{k}$. As a consequence, the interest rate $\hat{r}$ can be used conventionally by the central bank to stabilize prices in the economy. As an example, if the banking system issues too much loans with respect to the macroeconomic performance of the economy, a rise in the value of $\hat{k}$, by increasing the interest rate paid on loans, may reduce the incentives to borrow. It thus reduces the incentive for risk taking and builds up buffers *ex-ante* to avoid a financial crisis.

However, a new question arises as the two policy instruments can not be set independently. First, concentrating on the FA' relation, *ceteris paribus* (for a given output gap), an increase in the interest rate $\hat{r}$ leads to a reduction of the interest rate spread which may affect the value of $\hat{k}$ set by the macroprudential authorities. Second, the bank capital requirement $\hat{k}$ affects the interest rate spread, and thereby the output gap, which in turn affects the interest rate $\hat{r}$.

To discuss monetary and macroprudential policy mix, we follow De Paoli & Paustian (2013): we assume that the monetary authority cares about the social welfare function except for the credit spread term, because the latter is taken care of by the macroprudential authority. Similarly, the macroprudential authority cares about social welfare except for the inflation term, which it is taken care of by the monetary authority. Both

[6] In this simplified framework, the main difference between the capital requirement instrument and the rate of reserves of banks is that the first instrument accounts for the whole range of bank assets while the second one is set on private sector deposits.

authorities care about the output gap term because it is affected by nominal rigidities and credit frictions.

To contrast different solutions in the conduct of macroprudential policy, we compare a situation where the macroprudential agency and the central bank act independently (we compute the Nash equilibrium of the model) with a situation where both the policy interest rate and the bank capital requirement are determined jointly by a common policy agency (we compute the cooperative equilibrium of the model).

4.2.1 The Nash equilibrium

In this situation, the objective of the monetary authorities is identical to the case studied in section 3.1: they minimize the loss function $\mathcal{L}$ subject to the Phillips curve PC. The targeting rule of the monetary authorities is still given by the previous relations, so the output and inflation gaps are still given by the values reported in the first column of Table 1.3.

	Nash Equilibrium		Cooperative Equilibrium
$(\hat{\pi} - \pi_0)$	$\left\lvert \frac{1}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S \right\rvert$	$<$	$\left\lvert \frac{2}{(2+\sigma_y^2\lambda_\pi)}\hat{\epsilon}_S \right\rvert$
$\hat{y}$	$\left\lvert \frac{-\sigma_y\lambda_\pi}{1+\sigma_y^2\gamma_1}\hat{\epsilon}_S \right\rvert$	$>$	$\left\lvert \frac{-\sigma_y\lambda_\pi}{(2+\sigma_y^2\lambda_\pi)}\hat{\epsilon}_S \right\rvert$
$\hat{\rho} - \hat{r}$	$\left\lvert \frac{-\sigma_y\lambda_\pi}{\theta_y\lambda_\rho}\frac{1}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S \right\rvert$	$>$	0

TABLE 1.3: A comparison of the Nash and cooperative equilibriums

The novelty in the analysis comes from the introduction of macroprudential decisions. The role of the macroprudential authority can be set as follows: according to De Paoli & Paustian (2013), it minimizes a loss function ($\mathcal{M}$) combining the output gap and the interest rate gap:

$$\mathcal{M} = \frac{1}{2}\hat{y}^2 + \frac{\lambda_\rho}{2}(\hat{\rho} - \hat{r})^2,$$

subject to FA' (equation (1.8)). The targeting rule that solves this policy problem is defined as:

$$\theta_y\lambda_\rho(\hat{\rho} - \hat{r}) = \hat{y}.$$

Namely, the optimal balance between both targets of the macroprudential authority accounts for the reluctance of financial stress (λ_ρ) in the society as well as the procyclicality parameter (θ_y) of financial decisions. Combining this targeting rule with the reduced form of the output gap obtained from the solution of the central bank, we get the interest rate spread as:

$$(\hat{\rho} - \hat{r})^{Nash} = -\frac{\sigma_y \lambda_\pi}{\theta_y \lambda_\rho} \frac{1}{1 + \sigma_y^2 \lambda_\pi} \hat{\epsilon}_S.$$

The Nash equilibrium is summarized in the first column of Table 1.3. The monetary policy stance to reach this situation is obtained by introducing these values in the IS curve (to get the optimal interest rate reaction of the authorities) while the macroprudential stance is obtained by combining the interest rate spread and the output gap with the FA' schedule. We thus get the following two instrument rules that support the Nash equilibrium of the model:

$$\begin{aligned} \hat{r}^{Nash} &= \frac{\alpha_r r_n}{(\alpha_r + \alpha_\rho)} + \frac{\sigma_y \lambda_\pi \left(\theta_y \lambda_\rho + \alpha_\rho\right)}{(\alpha_r + \alpha_\rho)\left(1 + \sigma_y^2 \lambda_\pi\right) \theta_y \lambda_\rho} \hat{\epsilon}_S + \frac{1}{(\alpha_r + \alpha_\rho)} \hat{\epsilon}_D, \\ \hat{k}^{Nash} &= -\frac{\left(1 + \theta_y^2 \lambda_\rho\right) \sigma_y \lambda_\pi}{\theta_k \theta_y \lambda_\rho \left(1 + \sigma_y^2 \lambda_\pi\right)} \hat{\epsilon}_S. \end{aligned}$$

As reported, by these two expressions, monetary policy should respond to both demand and supply shocks, while the macroprudential instrument should only respond to supply shocks. Given the *"divine coincidence"*, the central bank can annihilate completely the transmission of demand shocks on the macroeconomy so the macroprudential authorities just react to supply shocks. In the Nash equilibrium, both authorities take into account output stability in their policy decision: the central bank concentrates on the relation between output stability and price stability while the macroprudential authorities concentrate on the link between output stability and financial stability. As each authorities has to balance two objectives, they are not able to close perfectly the gaps following supply shocks.

Furthermore, each authority neglects the fact that their policy decisions have an impact on the other authority objectives. When the central bank sets a higher interest rate to stabilize the output gap following an adverse supply shock, it increases the interest rate spread, thus requiring a decrease in the value of $\hat{k}$ to keep the interest rate spread unchanged; Inversely if the macroprudential authorities set a higher value of $\hat{k}$, it increases the interest rate spread which depresses the output gap and leads to deflation thus requiring a decrease in the interest rate to stabilize the output gap. This kind of conflicting situation may set the ground for creating agencies in charge of implementing both policies in a cooperative way.

4.2.2 The cooperative equilibrium

To evaluate the social benefit of cooperation in the setting of the two policy instruments, we assume that both authorities are treated equally by a common agency that minimizes a loss function $\mathcal{N}$ defined as the average of the two other authorities ($i.e.$, $\mathcal{N}=\frac{1}{2}(\mathcal{L}+\mathcal{M})$). Formally, this agency aims at minimizing:

$$\mathcal{N} = \frac{1}{2}\hat{y}^2 + \frac{\lambda_\pi}{4}(\hat{\pi} - \pi_0)^2 + \frac{\lambda_\rho}{4}(\hat{\rho} - \hat{r})^2,$$

subject to the Phillips curve PC (equation (1.1)) and the financial accelerator FA' (equation (1.8)). The targeting rule of the joint authority is now defined as:

$$\hat{y} = -\sigma_y \frac{\lambda_\pi}{2}(\hat{\pi} - \pi_0) + \theta_y \frac{\lambda_\rho}{2}(\hat{\rho} - \hat{r}).$$

The equilibrium solution of the model is obtained by finding five variables with only four equations. The only possibility to get a solution in this situation is to proceed sequentially as follows: the cooperative situation allows the joint authority to close the interest rate spread ($\hat{\rho}-\hat{r} = 0$ in equation (1.8)), so that the macroprudential instrument should be set according to:

$$\hat{k} = \frac{\theta_y}{\theta_k}\hat{y}.$$

This result illustrates the *Mundellian Policy Assignment principle*: in the cooperative equilibrium, capital requirements should be specialized to address the procyclicality problem. This instrument must be set (proportionally to the elasticity θ_y) with respect to the fluctuations in the output gap. In this case, the targeting rule of the authorities degenerates to:

$$\hat{y} = -\sigma_y \frac{\lambda_\pi}{2}(\hat{\pi} - \pi_0),$$

which combined with the Phillips curve, leads to:

$$\hat{y} = -\frac{\sigma_y \lambda_\pi}{(2 + \sigma_y^2 \lambda_\pi)}\hat{\epsilon}_S,$$
$$\hat{\pi} - \pi_0 = \frac{2}{(2 + \sigma_y^2 \lambda_\pi)}\hat{\epsilon}_S.$$

The cooperative equilibrium requires the policy stance to be defined as follows:

$$\hat{k}^{Coop} = -\frac{\theta_y}{\theta_k}\frac{\sigma_y \lambda_\pi}{(2 + \sigma_y^2 \lambda_\pi)}\hat{\epsilon}_S,$$
$$\hat{r}^{Coop} = \frac{\alpha_r r_n}{(\alpha_r + \alpha_\rho)} + \frac{1}{(\alpha_r + \alpha_\rho)}\hat{\epsilon}_D + \frac{(1 - \alpha_\rho \theta_y)}{(\alpha_r + \alpha_\rho)}\frac{\sigma_y \lambda_\pi}{(2 + \sigma_y^2 \lambda_\pi)}\hat{\epsilon}_S.$$

As reported in Table 1.3, the cooperative solution leads to better results in terms of interest rate spread and output gap: closing the interest rate spread solves the financial distortion in the economy which in turn has a clear dampening effect on the output gap. In contrast the Nash equilibrium leads to a better inflation performance. These two results can be understood as follows. First keeping independent authorities is better for inflation performance. The specialization of the central bank allows this institution to reach a lower inflation rate in the economy. However, in this situation, both the output gap and the interest rate spread are higher. Thus, such a monetary policy exacerbates financial problems, which in turn leads to more output contraction. In the Nash equilibrium, the central bank does not take into account the effect of the capital requirement instrument on the output gap. By neglecting the impact of $\hat{k}$ on $\hat{y}$ through the value of $\hat{\rho}$, it tends to increase or decrease too much the interest rate. This leads to a higher volatility of the interest rate spread which in turn leads to too much variability of the output gap. Second, in the cooperative solution, inflation rate is higher because the central bank takes into account the destabilizing impact of a tight monetary policy on financial stability. By so, the interest rate stance is lower, which leads to more inflation but dampens the interest rate spread and, as a consequence, limits the output contraction in the economy. The cooperative setting of both instruments has also one main advantage: now the objective of output stability is not shared by two distinct authorities that may take conflicting decisions in terms of instrument setting. Cooperation thus allows the joint agency to close the interest rate spread so as to avoid the impact of destabilizing financial decisions on activity.

The ranking of these two policies should be done by contrasting the level of welfare loss in the economy under the two situations. Consolidating the reduced form of the three "gaps" and the loss functions, we get:

$$\mathbf{N}^{Nash} = \frac{1}{2}\left(-\frac{\sigma_y\lambda_\pi}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S\right)^2 + \frac{\lambda_\pi}{2}\left(\frac{1}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S\right)^2 + \frac{\lambda_\rho}{2}\left(\frac{-\sigma_y\lambda_\pi}{\theta_y\lambda_\rho}\frac{1}{1+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S\right)^2,$$

and:

$$\mathbf{N}^{Coop} = \frac{1}{2}\left(-\frac{\sigma_y\lambda_\pi}{2+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S\right)^2 + \frac{\lambda_\pi}{4}\left(\frac{2}{2+\sigma_y^2\lambda_\pi}\hat{\epsilon}_S\right)^2.$$

Contrasting both values of the loss function, we see that the final ranking between the two institutional arrangements depends on some parameters related to the society preferences with respect to price stability (λ_π) and financial stability (λ_ρ).

In Figure 1.3, we simulated the two loss functions using parameter values provided by Cecchetti & Li (2008)[7]. As reported, the cooperative solution is always better, as the

[7]Parameters are set as follows: $\sigma_y = 0.10$, $\alpha_r = 0.75$, $\alpha_\rho = 0.75$, $b = 0.15$, $\tau = 0.90$, $\delta_y = 0.20$, $\delta_r = 0.00$, $l_y = 0.00$, $l_\rho = 1.00$. The standard deviation of the supply shock is set equal to 1.00. Finally, we set $\lambda_\rho = 1.00$

loss function is lower in the cooperative regime for any value of λ_π. By solving a problem of externalities in the individual setting of policy instruments, the cooperative solution is Pareto improving. Remarkably, the optimality of the cooperative solution increases with the society inflation reluctance parameter. Indeed, in this situation, specializing macroprudential policy to close the interest rate spread has a direct stabilizing impact on the output gap, which in turn implies less inflationary problems in the economy. Thus, the goal of price stability should be completed with an objective of macrofinancial stability to improve welfare in the economy. Both instruments should be set cooperatively.

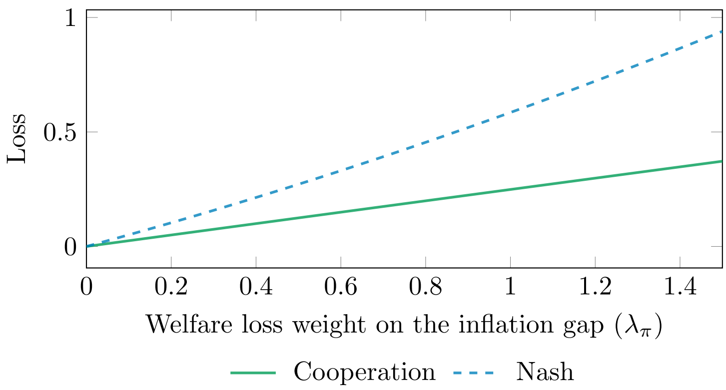


FIGURE 1.3: Welfare loss for different values of λ_π with Cooperative and Nash implementations.

5 Conclusion

The implementation of macroprudential measures is becoming a generalized practice in developed economies to prevent the building of financial imbalances such as the ones that led to the crisis of 2007-2009.

In this chapter, we used a static version of the New Keynesian Macroeconomics model to concentrate on the key aspects of the question. To get a clear understanding, we insisted on three main "gaps": the output gap (*i.e.*, the difference between actual and full employment output), the inflation gap (*i.e.*, the difference between the actual and the targeted inflation rate) and the interest rate spread (*i.e.*, the difference between the interest rate on loans and the interest rate of the central bank).

We discussed three main points. First, assuming that monetary authorities follow a simple interest rate rule, we evaluated the consequences of taking into account the working of the banking system in shaping the transmission of supply and demand shocks. Second, we discussed the possibility to extend monetary policy to follow financial stability objectives, assuming that the central bank implements an optimal monetary policy. In this situation we outlined the cost of this policy in term of price stability so that the introduction of macroprudential measures can be useful to solve a problem of missing instrument following Tinbergen (1952). Third, we discussed the nature of macroprudential policy, accounting for the fact that this is a debated question regarding both the choice of instruments and the way such decisions should be taken in relation with the conduct of monetary policy. We illustrated this question in a situation where the macroprudential instrument is the capital requirement of the banking sector by contrasting a Nash and a cooperative equilibrium. As shown, independence in the decision process between the two authorities leads to better results in terms of price stability (lower inflation rate). In contrast, the cooperative solution leads to better results in terms of output stability and lower interest rate spread.

The analysis provided in this chapter can be extended in various directions for higher level students. To name just a few possibilities, it is easy to relax the assumption of a unitary interest rate pass through, to evaluate the nature of the macroprudential policy when the divine coincidence does not hold. A second interesting possibility should be to analyze the optimal macroprudential policy in an open economy to evaluate the gain that can obtained by coordinating national decisions in a world of perfect capital mobility.

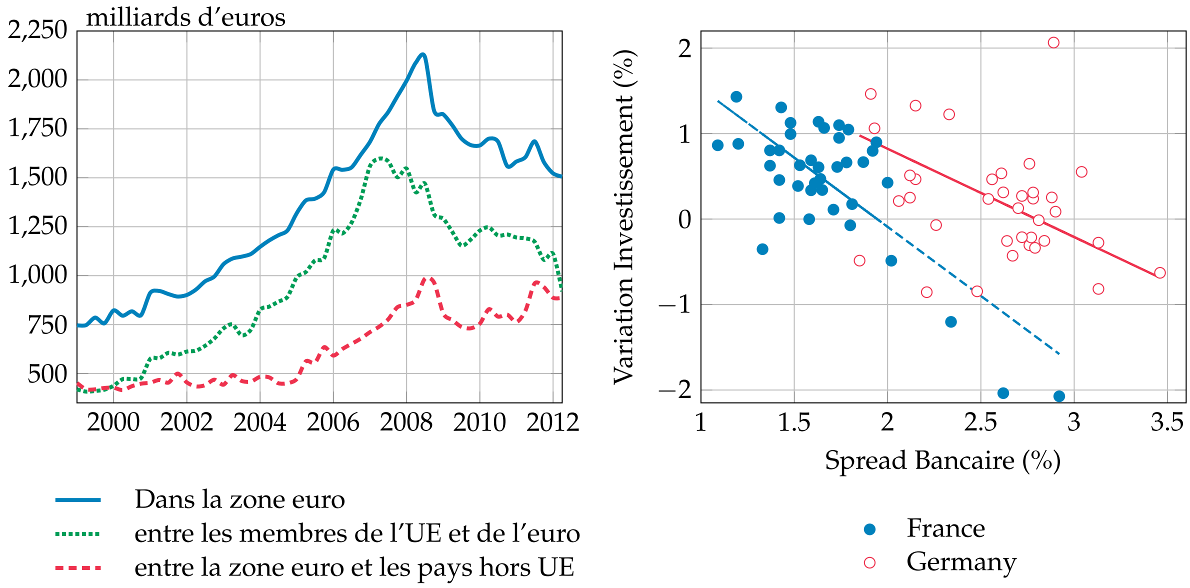
Chapter 2

Cross-border Corporate Loans and International Business Cycles in a Monetary Union

1 Introduction

En éliminant le risque de change, l'adoption de l'Euro en 1999 a favorisé le développement des prêts transfrontaliers entre les pays membres de l'UEM (Forster et al., 2011; Brunnermeier et al., 2012). Comme on peut le voir sur la Figure 2.1.a, le montant de ces prêts a triplé en 9 ans, passant de 750 milliards d'euros en 1999 à plus de 2.100 milliards en 2008. Au moment du déclenchement de la crise financière il représentait 24% du PIB des membres de l'UEM, avant de baisser fortement, introduisant de fait un mécanisme potentiellement récessif dans la zone euro. Le rôle critique de ces prêts transfrontaliers est renforcé par le fait que les banques européennes sont la source principale de financement des ménages et entreprises de la zone euro. Ainsi, en 2012, le secteur bancaire de la zone euro avait une taille 4,5 fois plus importante que le secteur bancaire américain et représentait 347% du PIB de la zone (contre seulement 74% du PIB pour le secteur bancaire US).

L'objectif de cet article est d'apprécier dans quelle mesure le développement des prêts transfrontaliers a affecté la diffusion des chocs asymétriques et la transmission des décisions de politique monétaire dans la zone euro. A cette fin nous construisons un modèle DSGE à deux pays dans lequel les flux bancaires transfrontaliers sont déterminés



(a) Prêts transfrontaliers des banques résidant dans la zone euro

(b) L'accélérateur bancaire: relation inverse entre tension bancaire et variation de l'investissement

FIGURE 2.1: Evolution et tensions du secteur bancaire depuis la création de l'euro.

de manière endogène[1]. Ce modèle, prenant en compte le mécanisme d'accélérateur financier (comme visible sur la Figure 2.1.b), est estimé à l'aide de l'économétrie bayesienne sur données allemandes et françaises entre le premier trimestre 2003 et le quatrième trimestre 2012.

En comparant une situation de segmentation totale des marchés bancaires nationaux avec la situation estimée, on observe que les prêts transfrontaliers amplifient la transmission des chocs entre les pays. Ce canal augmente la taille de la volatilité des variables dans le pays qui subit le choc, détériore de manière significative la situation macroéconomique de l'autre pays et renforce la persistance des chocs sur le solde du compte courant et sur l'activité conjointe des deux pays. La décomposition de la variance des principales variables d'intérêt du modèle permet d'observer que ce canal transfrontalier a eu plus d'impact sur la France que sur l'Allemagne et qu'il a renforcé la diffusion des chocs financiers entre les deux pays. De plus, on observe que le taux d'intérêt directeur de la BCE est devenu plus sensible aux chocs de nature financière (dans leur ensemble, les chocs financiers expliquent 46,7% de la variabilité du taux d'intérêt directeur, contre 41,8% lorsque les marchés bancaires sont segmentés) aux dépends des chocs réels (qui expliquent 40,3% de la variance du taux directeur au lieu de 44,8% lorsque les marchés bancaires sont segmentés).

[1]Cette dimension est nouvelle dans la littérature existante qui décrit l'UEM soit à l'aide de modèles à un pays (par exemple Gerali et al. (2010)) supposant de fait une parfaite intégration du marché bancaire au sein de la zone euro, soit en utilisant des modèles à deux pays (par exemple Faia (2007); Kollmann et al. (2011)) ignorant les échanges bancaires transfrontaliers.

La structure de l'article est la suivante: la Section 2 présente le modèle; la Section 3 est consacrée à l'estimation du modèle; la Section 4 évalue l'impact des prêts transfrontaliers sur la diffusion de chocs asymétriques et présente la décomposition de la variance historique des principales variables du modèle. La Section 5 conclut.

2 Une union monétaire avec prêts transfrontaliers

Cette section présente un modèle d'union monétaire à deux pays introduisant les flux bancaires transfrontaliers dans un cadre initialement développé par Christiano et al. (2005) et Smets & Wouters (2007)[2]. La structure générale du cadre d'analyse est résumée par la Figure 2.2. Chaque pays $i \in \{h, f\}$ (où h désigne le pays domestique et f le pays étranger) est peuplé de consommateurs, de syndicats, d'entreprises (intermédiaires et finale), d'entrepreneurs, de capitalistes et de banques. Concernant les autorités, les politiques budgétaires sont menées par les gouvernements nationaux alors que la politique monétaire est sous le contrôle d'une banque centrale unique. Dans cette section, on présente successivement les déterminants des flux bancaires transfrontaliers, le reste du modèle et les conditions d'équilibre général.

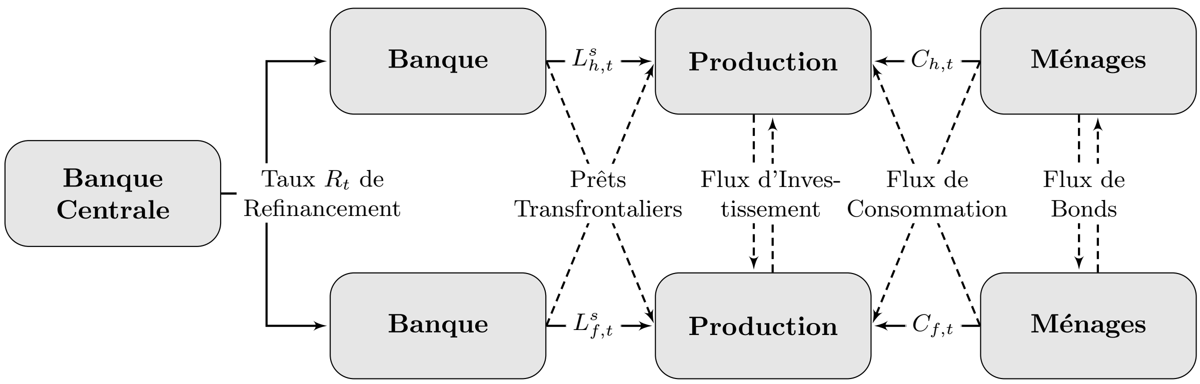


FIGURE 2.2: Le modèle d'une union monétaire à deux pays avec des prêts transfrontaliers

2.1 Choix d'investissement et flux bancaires transfrontaliers

Les flux bancaires internationaux proviennent des choix effectués par l'entrepreneur pour financer le capital utilisé par les firmes qui fabriquent les biens intermédiaires. L'entrepreneur représentatif $e \in [0, 1]$ finance un grand nombre de projets dont la valeur totale est $Q_{i,t}K_{i,t+1}(e)$ (avec $Q_{i,t}$ représentant le prix du capital et $K_{i,t+1}(e)$ le montant

[2] Comme Smets et Wouters, nous prenons en compte de nombreuses rigidités réelles (habitudes de consommation, coûts d'ajustement sur l'investissement et habitudes de demande de prêt) et nominales (une technologie de type calvo caractérise l'ajustement imparfait des prix des biens finaux, des salaires et des taux d'intérêt des prêts) afin d'accroître le pouvoir explicatif de ce modèle et de préciser l'origine des hétérogénéités nationales lors de son estimation.

de capital choisi) à l'aide de sa richesse nette (égale à $N_{i,t}(e)$ en termes réels) et en empruntant un montant $L^d_{i,t+1}(e)$ auprès des banques domestiques et étrangères. On suppose que l'entrepreneur a des habitudes d'emprunt externes (mesurées par le paramètre h^L_i) afin d'améliorer l'estimation du modèle[3], et donc que le montant de prêt effectif de prêts contracté par l'entrepreneur est de $L^{\mathcal{H}}_{i,t+1}(e) = L^d_{i,t+1}(e) - h^L_i \left(L^d_{i,t+1} - \bar{L}^d_i \right)$. Ainsi, le bilan de cet agent s'écrit:

$$Q_{i,t}K_{i,t+1}(e) = L^{\mathcal{H}}_{i,t+1}(e) + P^c_{i,t}N_{i,t+1}(e) \tag{2.1}$$

. La valeur totale des prêts contractés est:

$$L^d_{i,t+1}(e) = \left(\left(1-\alpha^L_i\right)^{1/\nu} L^d_{h,i,t+1}(e)^{(\nu-1)/\nu} + \left(\alpha^L_i\right)^{1/\nu} L^d_{f,i,t+1}(e)^{(\nu-1)/\nu} \right)^{\nu/(\nu-1)}, \tag{2.2}$$

où le paramètre ν représente l'élasticité de substitution entre les prêts domestiques et étrangers, α^L_i le pourcentage des prêts transfrontaliers[4] et $L^d_{h,i,t+1}(e)$ (resp. $L^d_{f,i,t+1}(e)$) le montant de prêts domestiques (resp. étrangers) demandés par l'entrepreneur e du pays i sont déterminés par:

$$L^d_{h,i,t+1}(e) = \left(1-\alpha^L_i\right) \left[\frac{R^L_{h,t}(e)}{P^L_{i,t}(e)} \right]^{-\nu} L^d_{i,t+1}(e), \tag{2.3}$$

$$L^d_{f,i,t+1}(e) = \alpha^L_i \left[\frac{R^L_{f,t}(e)}{P^L_{i,t}(e)} \right]^{-\nu} L^d_{i,t+1}(e), \tag{2.4}$$

où $P^L_{i,t}(e) = ((1-\alpha^L_i) R^L_{h,t}(e)^{1-\nu} + \alpha^L_i R^L_{f,t}(e)^{1-\nu})^{1/(1-\nu)}$, représente le coût total des prêts contractés et $R^L_{h,t}(e)$ (resp. $R^L_{f,t}(e)$) le coût des prêts obtenus dans l'économie domestique (resp. étrangère) par l'entrepreneur e du pays i.

Dans ce modèle, l'entrepreneur a une mauvaise appréciation du rendement de ses projets. Comme De Grauwe (2010), on suppose qu'il est optimiste et qu'il sur-estime *ex ante* ses revenus futurs. Ce phénomène permet de générer un mécanisme d'accélération du même type que celui de Bernanke et al. (1999) sans avoir recours à des coûts d'agence. Dans ce cadre, nous remplaçons la distribution log-normale des contrats par une distribution de Pareto qui permet une présentation plus simple de la forme log linéaire du modèle qui servira à l'estimation[5]. On suppose que chaque entrepreneur e diversifie ses projets d'investissement sur un ensemble $\omega \in [0, +\infty[$ où ω suit une loi de Pareto. Le rendement

[3] Ce paramètre permet de tenir compte du fait que dans les données la maturité des prêts est supérieure au trimestre, unité de temps utilisée dans ce modèle pour définir une période de l'analyse.

[4] Ce paramètre est estimé dans le modèle et comparé à une valeur nulle afin de préciser l'influence macroéconomique des prêts transfrontaliers. Ce biais dans la demande de prêt peut être justifié en supposant un coût plus élevé pour se procurer des prêts étrangers, comme dans la littérature sur les coûts de transports iceberg à la Obstfeld & Rogoff (2001). Le lien entre le biais et les coûts iceberg est présenté par Eyquem & Poutineau (2010).

[5] Les caractéristiques de la distribution de Pareto sont présentées en annexe.

agrégé des projets d'investissement est $R^k_{i,t}$, chaque projet ω a un rendement $\omega R^k_{i,t}$, le profit de chaque projet est $\Pi^E_{i,t}(e,\omega) = \omega R^k_{i,t} Q_{i,t-1} K_{i,t}(e,\omega) - P^L_{i,t-1}(e) L^{\mathcal{H}}_{i,t}(e,\omega)$. Le seuil séparant les projets viables des projets non viables $\omega^C_{i,t}$ est tel que $\Pi_{i,t}\left(e, \omega^C_{i,t}\right) = 0$:

$$\omega^C_{i,t} R^k_{i,t} Q_{i,t-1} K_{i,t}\left(e, \omega^C_{i,t}\right) = P^L_{i,t-1}(e) L^{\mathcal{H}}_{i,t}\left(e, \omega^C_{i,t}\right). \tag{2.5}$$

En agrégeant tous les projets rentables de l'entrepreneur $\int_{\omega^C_{i,t}(e)}^{+\infty} \Pi_{i,t}(e,\omega) \mathrm{d}\omega$, on obtient $\bar{\omega}_{i,t}(e)$ qui est l'espérance conditionnelle de ω sachant que les projets sont viables (voir annexe en fin de thèse). Cependant on suppose que, dans sa prise de décision, l'entrepreneur est optimiste car il tend à sur-estimer le rendement futur de son investissement (De Grauwe, 2010). On introduit cette caractéristique à l'aide de la fonction:

$$g(\bar{\omega}_{i,t+1}, \varepsilon^Q_{i,t}) = \gamma_i (\bar{\omega}_{i,t+1} (e^{\varepsilon^Q_{i,t}})^{1/\varkappa_i})^{\varkappa_i/(\varkappa_i - 1)},$$

où $\varepsilon^Q_{i,t}$ représente un choc exogène suivant un processus $AR(1)$[6] et $\varkappa_i$ l'élasticité de prime de financement externe. Cette fonction est telle que $\forall \bar{\omega}_{i,t} > 1$, $g(\bar{\omega}_{i,t}) > \bar{\omega}_{i,t}$ pour des valeurs positives des paramètres γ_i et $\varkappa_i$. *Ex-ante*, l'entrepreneur choisit un montant de capital à financer $K_{i,t+1}(e)$ qui maximise son profit espéré $\Pi^E_{i,t+1}(e)$ compte tenu de cette appréciation biaisée du rendement de son projet:

$$\max_{\{K_{i,t+1}(e)\}} E_t \left\{ \eta^E_{i,t+1} \left[g\left(\bar{\omega}_{i,t+1} \left(e^{\varepsilon^Q_{i,t}} \right)^{\frac{1}{\varkappa_i}} \right) R^k_{i,t+1} Q_{i,t} K_{i,t+1}(e) - P^L_{i,t}(e) L^{\mathcal{H}}_{i,t+1}(e) \right] \right\}, \tag{2.6}$$

où $\eta^E_{i,t+1}$ est la part espéré des projets viables (décrit en annexe). En utilisant les caractéristiques de la distribution de Pareto, le spread espéré demandé par l'entrepreneur s'écrit:

$$S_{i,t}(e) = \frac{E_t R^k_{i,t+1}}{P^L_{i,t}(e)} = \gamma_i^{\varkappa_i - 1} \left[\frac{\kappa}{\kappa - 1} \left(1 - \frac{P^C_{i,t} N_{i,t+1}(e)}{Q_{i,t} K_{i,t+1}(e)} \right) \right]^{\varkappa_i} e^{\varepsilon^Q_{i,t}}. \tag{2.7}$$

L'ampleur de l'accélérateur est déterminée par l'élasticité $\varkappa_i$. Pour toute valeur $\varkappa_i > 0$, la prime de financement externe $S_{i,t}(e)$ est une fonction positive du ratio de solvabilité, $Q_{i,t} K_{i,t+1}(e) / N_{i,t+1}(e)$, de sorte qu'une augmentation de la richesse nette $N_{i,t+1}(e)$ induit une réduction de la prime de financement externe $S_{i,t}(e)$[7]. Quand $\varkappa_i = 0$, le spread disparait. Le montant de capital des projets non viables, $\left(1 - \eta^E_{i,t}\right) \underline{\omega}_{i,t}(e) R^k_{i,t} Q_{i,t-1} K_{i,t}(e)$, est consommé en biens domestiques. De fait, la richesse nette de l'entrepreneur évolue

[6] Ce choc exogène augmente la prime de risque des obligations ce qui provoque une augmentation du coût du capital et *in fine* une réduction des investissements (Gilchrist, Sim, & Zakrajsek, 2009). Le choc exogène qui affecte le rendement des projets est corrigé par l'exposant $1/\varkappa_i$ afin de normaliser l'impact de ce choc à l'unité dans la forme log linéaire du modèle. Enfin, $\gamma_i = \overline{\omega}^{1-\varkappa_i/(\varkappa_i - 1)}$ est un paramètre d'échelle de manière à obtenir un état stationnaire indépendant de $\varkappa_i$.

[7] En définissant par $\hat{x}_{i,t}$ la déviation logarithmique d'une variable quelconque $X_{i,t}$ par rapport à sa valeur stationnaire, la valeur agrégée de la déviation logarithmique du spread par rapport à l'état stationnaire ($\hat{s}_{i,t}$) a la forme standard introduite à la suite des travaux de Bernanke et al. (1999), $\hat{s}_{i,t} = E_t \hat{r}^k_{i,t+1} - \hat{p}^L_{i,t} = \varkappa_i \frac{\bar{N}/\bar{K}}{1 - \bar{N}/\bar{K}} \left(\hat{q}_{i,t} + \hat{k}_{i,t+1} - \hat{n}_{i,t+1} \right) + \varepsilon^Q_{i,t}$.

selon l'expression:

$$N_{i,t+1}(e) = \left(1 - \tau^E\right) \frac{\Pi^E_{i,t}(e)}{e^{\varepsilon^N_{i,t}}}, \tag{2.8}$$

où $\varepsilon^N_{i,t}$ est un processus exogène de destruction de richesse nette et τ^E est une taxe proportionnelle sur l'accumulation des profits de l'entrepreneur.

2.2 Le reste du modèle

2.2.1 Les ménages

Chaque économie est peuplée par un grand nombre de ménages normalisé à 1. Le ménage représentatif $j \in [0,1]$ évalue son utilité en termes de consommation et d'effort de travail. Il maximise son bien-être défini comme la somme actualisée des utilités courante et futures:

$$\max_{\left\{\substack{C_{i,t}(j), H_{i,t}(j),\\ B_{i,t+1}(j)}\right\}} \mathrm{E}_t \sum_{\tau=0}^{\infty} \beta^\tau e^{\varepsilon^U_{i,t+\tau}} \left(\frac{\left(C_{i,t+\tau}(j) - h^C_i C_{i,t-1+\tau}\right)^{1-\sigma^C_i}}{1-\sigma^C_i} - \chi_i \frac{H_{i,t+\tau}^{1+\frac{1}{\sigma^L_i}}(j)}{1+\frac{1}{\sigma^L_i}} \right), \tag{2.9}$$

sous contrainte de son budget:

$$\frac{W^h_{i,t}}{P^C_{i,t}} H_{i,t}(j) + R_{t-1} \frac{B_{i,t}(j)}{P^C_{i,t}} + \frac{\Pi_{i,t}(j)}{P^C_{i,t}} = C_{i,t}(j) + \frac{B_{i,t+1}(j)}{P^C_{i,t}} + \frac{T_{i,t}(j)}{P^C_{i,t}} + \frac{P_{i,t}}{P^C_{i,t}} AC^B_{i,t}(j). \tag{2.10}$$

Dans ces relations:

$$C_{i,t}(j) = (\left(1-\alpha^C_i\right)^{1/\mu} C_{h,i,t}(j)^{(\mu-1)/\mu} + \left(\alpha^C_i\right)^{1/\mu} C_{f,i,t}(j)^{(\mu-1)/\mu})^{\mu/(\mu-1)}, \tag{2.11}$$

est l'indice de consommation composé de biens domestiques et étrangers où α^C_i est la part de biens étrangers dans le panier de consommation du ménage et μ est l'élasticité de substitution entre les biens domestiques et étrangers. L'indice des prix à la consommation du ménage s'écrit:

$$P^C_{i,t} = ((1-\alpha^C_i) P^{1-\mu}_{h,t} + \alpha^C_i P^{1-\mu}_{f,t})^{1/(1-\mu)}, \tag{2.12}$$

où $P_{i,t} = (\int_0^1 P_{i,t}(i)^{1-\epsilon_P} \mathrm{d}i)^{1/(1-\epsilon_P)}$ est le prix du bien final fabriqué dans l'économie i. Par ailleurs, $h^C_i \in [0,1]$ est un paramètre qui représente les habitudes externes de consommation de chaque ménage, σ^C_i est le taux d'aversion au risque de consommation, $H_{i,t}(j)$ est la fraction de temps dans une journée consacrée au travail, σ^L_i est l'élasticité frischienne et $\varepsilon^U_{i,t}$ est un choc exogène de préférence suivant un processus $AR(1)$. Les ressources du ménage sont composées de ses revenus du travail $H_{i,t}(j)\, W^h_{i,t}/P^C_{i,t}$, de son épargne $B_{i,t}(j)$ rémunérée à un taux R_{t-1} et de dividendes

$\Pi_{i,t}(j)$ liés à sa détention d'actions[8]. Du côté des dépenses, le ménage représentatif consomme $C_{i,t}(j)$, épargne $B_{i,t+1}(j)$ et paie des impôts $T_{i,t}(j)$. Afin d'éviter que le ménage n'épargne indéfiniment, on suppose qu'il paie des coûts d'ajustement de la forme $AC_{i,t}^B(j) = \frac{\chi^B}{2}(B_{i,t+1}(j) - B_i(j))^2$ comme suggéré par Schmitt-Grohé & Uribe (2003), où $B_i(j)$ est le niveau d'épargne de long terme de l'économie. Après résolution du problème 2.9 sous contrainte de budget 2.10, les conditions de premier ordre se résument à une équation d'Euler:

$$\frac{\beta R_t}{1 + P_{i,t}\chi^B(B_{i,t+1}(j) - B_i(j))} = E_t\left\{\frac{e^{\varepsilon^U_{i,t}}}{e^{\varepsilon^U_{i,t+1}}}\frac{P^C_{i,t+1}}{P^C_{i,t}}\left(\frac{(C_{i,t+1}(j) - h_i^C C_{i,t})}{(C_{i,t}(j) - h_i^C C_{i,t-1})}\right)^{\sigma_i^C}\right\}, \tag{2.13}$$

décrivant la trajectoire optimale de consommation et a une fonction d'offre de travail:

$$\frac{W^h_{i,t}}{P^C_{i,t}} = \chi_i H_{i,t}(j)^{\frac{1}{\sigma_i^L}}\left(C_{i,t}(j) - h_i^C C_{i,t-1}\right)^{\sigma_i^C}. \tag{2.14}$$

2.2.2 Les syndicats

De nombreuses études empiriques montrent que les salaires sont rigides au sens où ils réagissent peu aux chocs économiques et sont indexés sur l'inflation. Pour introduire ces aspects dans le modèle on suppose, comme Smets & Wouters (2007), qu'il existe un syndicat représentatif chargé par le ménage $j \in [0,1]$ de renégocier son salaire à chaque période. Le salaire désiré par le ménage est $W^h_{i,t}$ (il correspond à l'utilité marginale du travail), mais en présence de rigidités nominales celui-ci ne s'ajuste pas aux nouvelles conditions économiques. Le syndicat intervient en négociant le salaire $W_{i,t}(j)$. Toutefois, une part θ_i^W des syndicats échoue à négocier un changement de salaire, celui-ci reste à sa valeur précédente, $W_{i,t} = \left(\pi^C_{i,t-1}\right)^{\xi_i^W} W_{i,t-1}$ et demeure indexé sur l'inflation dans une proportion ξ_i^W. Pour la partie $1 - \theta_i^W$ des syndicats en mesure de renégocier le salaire, chaque syndicat j choisit le salaire optimal $W^*_{i,t}(j)$ en maximisant cette somme actualisée des écarts entre le salaire désiré du ménage et son salaire effectif:

$$\max_{\{W^*_{i,t}(j)\}} E_t\left\{\sum_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^\tau\frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}}\left[\left(1-\tau^W\right)\frac{W^*_{i,t}(j)}{P^c_{i,t+\tau}}\left(\frac{P^C_{i,t+j-1}}{P^C_{i,t-1}}\right)^{\xi_i^W} - \frac{W^h_{i,t+\tau}}{P^C_{i,t+\tau}}\right]H_{i,t+\tau}(j)\right\}, \tag{2.15}$$

sous une contrainte:

$$H_{i,t+\tau}(j) = (W^*_{i,t}(j)/W_{i,t+\tau}\left(P^C_{i,t+\tau-1}/P^C_{i,t-1}\right)^{\xi_i^W})^{-\epsilon_W} H_{i,t+\tau},\ \forall\tau > 0,$$

[8]Les profits sont liés à la détention d'actions de firmes $\Pi^Y_{i,t}(j)$, de banques $\Pi^B_{i,t}(j)$ et de syndicats $\Pi^W_{i,t}(j)$ tel que $\Pi_{i,t}(j) = \Pi^Y_{i,t}(j) + \Pi^B_{i,t}(j) + \Pi^W_{i,t}(j)$.

représentant la demande de travail provenant d'un agent qui agrège de manière concurrentielle les quantités de travail $H_{i,t}(j)$ offertes par les ménages[9]. Le paramètre ϵ_W est l'élasticité de substitution entre les différentes variétés de travail. Pour simplifier le problème, on suppose que les gouvernements taxent les distorsions générées par la concurrence monopolistique $\tau^W = (1-\epsilon_W)^{-1}$. La condition de premier ordre est donnée par:

$$\sum_{\tau=0}^{\infty} \left(\theta_i^W \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[\frac{W_{i,t}^*(j)}{P_{i,t+\tau}^c} \left(\frac{P_{i,t+\tau-1}^c}{P_{i,t-1}^c} \right)^{\xi_i^W} - \frac{\epsilon_W}{(1-\tau^W)(\epsilon_W - 1)} \frac{W_{i,t+\tau}^h}{P_{i,t+\tau}^C} \right] H_{i,t+\tau}(j) = 0. \tag{2.16}$$

2.2.3 Les entreprises

Le secteur productif est peuplé de deux groupes d'agents: les firmes intermédiaires et la firme finale. Les firmes intermédiaires produisent des biens différenciés i en combinant du capital et du travail et fixent les prix selon une technologie à la Calvo. Le producteur du bien final agrège l'ensemble des variétés des firmes intermédiaires pour produire un bien final homogène[10]. La firme intermédiaire représentative $i \in [0,1]$ produit une quantité de bien intermédiaire par une technologie Cobb-Douglas:

$$Y_{i,t}(i) = e^{\varepsilon_{i,t}^A} K_{i,t}^u(i)^{\alpha} H_{i,t}^d(i)^{1-\alpha}, \tag{2.17}$$

en combinant du capital $K_{i,t}^u(i)$, du travail $H_{i,t}^d(i)$ et de la technologie $e^{\varepsilon_{i,t}^A}$. Cette technologie $\varepsilon_{i,t}^A$ est exogène et suit un processus $AR(1)$. Le profit de la firme représentative s'écrit, $P_{i,t}(i)Y_{i,t}(i) - Z_{i,t}K_{i,t}^u(i) - W_{i,t}H_{i,t}^d(i)$, où $P_{i,t}(i)$ est le prix du bien intermédiaire, $Z_{i,t}$ est la rémunération du capital et $W_{i,t}$ le salaire nominal. Elle résout un problème en deux étapes. Dans une première étape, elle va sur le marché parfaitement concurrentiel des facteurs de production et maximise des profits sous contrainte de production pour atteindre un coût marginal de production $MC_{i,t}(i)$:

$$MC_{i,t}(i) = MC_{i,t} = \frac{1}{e^{\varepsilon_{i,t}^A}} \left(\frac{Z_{i,t}}{\alpha} \right)^{\alpha} \left(\frac{W_{i,t}}{(1-\alpha)} \right)^{(1-\alpha)}. \tag{2.18}$$

[9] Cet agent agit en concurrence et maximise son profit, $W_{i,t}H_{i,t}^d - \int_0^1 W_{i,t}(j) H_{i,t}(j)\mathrm{d}j$, sous contrainte de production $H_{i,t}^d = (\int_0^1 H_{i,t}(j)^{(\epsilon_W-1)/\epsilon_W}\mathrm{d}j)^{\epsilon_W/(\epsilon_W-1)}$. Les fonctions de demande pour chaque variété j de travail s'écrit alors, $H_{i,t}(j) = (W_{i,t}(j)/W_{i,t})^{-\epsilon_W} H_{i,t}^d$, $\forall j$. Formellement, les ménages offrent différentes variétés de travail aux syndicats qui négocient les salaires, les variétés de travail sont ensuite agrégées par l'agent précédemment décrit.

[10] Le producteur final est en concurrence parfaite et maximise son profit, $P_{i,t}Y_{i,t}^d - \int_0^1 P_{i,t}(i)Y_{i,t}(i)\mathrm{d}i$, sous contrainte de production $Y_{i,t}^d = (\int_0^1 Y_{i,t}(i)^{(\epsilon_P-1)\epsilon_P}\mathrm{d}i)^{\epsilon_P/(\epsilon_P-1)}$. Les fonctions de demande pour chaque bien intermédiaire s'écrit alors, $Y_{i,t}(i) = (P_{i,t}(i)/P_{i,t})^{-\epsilon_P} Y_{i,t}^d$, $\forall i$. où $Y_{i,t}^d$ est la demande agrégée pour tous les biens.

Dans une deuxième étape, les firmes fixent leurs prix en concurrence monopolistique avec des rigidités nominales à la Calvo. A chaque période, une fraction θ_i^P de firmes ne peut changer optimalement son prix et s'indexe partiellement sur l'inflation précédente à un degré ξ_i^P tel que $P_{i,t}(i) = \pi_{i,t-1}^{\xi_i^P} P_{i,t-1}(i)$. Pour la fraction $1-\theta_i^P$ de firmes autorisées à changer de prix, elles choisissent $P_{i,t}^*(i)$ qui maximise la somme actualisée de profits, $\Pi_{i,t}^Y(i)$, qui s'écrit:

$$\max_{\{P_{i,t}^*(i)\}} E_t \left\{ \sum_{\tau=0}^{\infty} \left(\theta_i^P \beta\right)^\tau \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[\left(1-\tau^Y\right) P_{i,t}^*(i) \left(\frac{P_{i,t+\tau-1}}{P_{i,t-1}} \right)^{\xi_i^P} - MC_{i,t+\tau} \right] Y_{i,t+\tau}(i) \right\}, \tag{2.19}$$

sous contrainte de demande $Y_{i,t+\tau}(i) = \left((P_{i,t+\tau-1}/P_{i,t-1})^{\xi_i^P} P_{i,t}^*(i)/P_{i,t+\tau}\right)^{-\epsilon_P} Y_{i,t+\tau}$ des firmes finales, $\forall\tau > 0$ où $Y_{i,t}$ représente la quantité de biens produits dans le pays i, et $\tau^Y = (\epsilon_P - 1)^{-1}$ est une taxe proportionnelle qui enlève les distorsions de prix et $\lambda_{i,t}^c$ est l'utilité marginale d'une unité de consommation du ménage. La condition du premier ordre du problème précédent s'écrit:

$$E_t \sum_{\tau=0}^{\infty} \left(\theta_i^P \beta\right)^\tau \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left(\left(\frac{P_{i,t+\tau-1}}{P_{i,t-1}} \right)^{\xi_i^P} P_{i,t}^*(i) - \frac{\epsilon_P}{(\epsilon_P - 1)\left(1-\tau^Y\right)} MC_{i,t+\tau} \right) Y_{i,t+\tau}(i) = 0 \tag{2.20}$$

2.2.4 Le producteur de biens capitaux

Le producteur de biens capitaux $k \in [0,1]$ rachète le stock de capital déprécié $(1-\delta) Q_{i,t} K_{i,t}(k)$ et investit un montant $P_{i,t}^I I_{i,t}(k)$ afin de renouveler le stock de capital à la période suivante $Q_{i,t} K_{i,t+1}(k)$. Il maximise son profit, $\Pi_{i,t}^k(k) = Q_{i,t} K_{i,t+1}(k) - (1-\delta) Q_{i,t} K_{i,t}(k) - P_{i,t}^I I_{i,t}(k)$ sous sa contrainte d'accumulation du capital:

$$K_{i,t+1}(k) = \left(1 - AC_{i,t}^I(k)\right) I_{i,t}(k) + (1-\delta) K_{i,t}(k), \tag{2.21}$$

où $AC_{i,t}^I(k)$ représente les coûts d'ajustement sur l'investissement[11]. Le problème que doit résoudre chaque producteur de capitaux est:

$$\max_{\{I_{i,t}(k)\}} E_t \left\{ \sum_{\tau=0}^{\infty} \beta^\tau \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[Q_{i,t} \left(1 - \frac{\chi_i^I}{2} \left(\frac{I_{i,t}(k)}{I_{i,t-1}(k)} - 1 \right)^2 \right) I_{i,t}(k) - P_{i,t}^I I_{i,t}(k) \right] \right\}.$$

La condition du premier ordre solution de ce problème s'écrit:

$$Q_{i,t} = P_{i,t}^I + Q_{i,t} \frac{\partial \left(I_{i,t} AC_{i,t}^I \right)}{\partial I_{i,t}} + \beta \frac{\lambda_{i,t+1}^c}{\lambda_{i,t}^c} Q_{i,t+1} \frac{\partial \left(I_{i,t+1} AC_{i,t+1}^I \right)}{\partial I_{i,t}}. \tag{2.22}$$

[11] La présence de ces derniers permet de faire correspondre les cycles des capitaux avec les cycles réels des affaires. Ces coûts sont de la forme $AC_{i,t}^I(k) = (\chi_i^I/2)\left(I_{i,t}(k)/I_{i,t-1}(k) - 1\right)^2$, où χ_i^I est le degré de ces coûts d'ajustement.

Les producteurs de capitaux achètent des biens domestiques ou étrangers. De ce fait:

$$I_{i,t}(k) = ((1-\alpha_i^I)^{1/\mu} I_{h,i,t}(k)^{(\mu-1)/\mu} + (\alpha_i^I)^{1/\mu} I_{f,i,t}(k)^{(\mu-1)/\mu})^{\mu/(\mu-1)},$$

et son indice des prix s'écrit:

$$P_{i,t}^I = ((1-\alpha_i^I) P_{h,t}^{1-\mu} + \alpha_i^I P_{f,t}^{1-\mu})^{1/(1-\mu)}.$$

Dans cette expression, le paramètre μ est l'élasticité de substitution entre biens capitaux domestiques et étrangers et α_i^I est la part des biens étrangers dans ce panier. Comme Smets & Wouters (2003), on suppose que les producteurs de capitaux décident du niveau d'utilisation du capital dans la production intermédiaire tel que, $K_{i,t}^u = u_{i,t} K_{i,t-1}$, avec $u_{i,t}$ représentant le degré d'utilisation du capital. Comme Bernanke et al. (1999), la rentabilité d'une unité de capital entre t et $t+1$ s'écrit:

$$\frac{E_t R_{i,t+1}^k}{1 + P_{i,t}\chi^B (B_{i,t+1}(j) - B_i(j))} = \frac{E_t Z_{i,t+1} u_{i,t+1} - \Phi(u_{i,t+1}) + (1-\delta) E_t Q_{i,t+1}}{Q_{i,t}}, \quad (2.23)$$

où $\Phi(u_{i,t+1})$ est la fonction coût de l'utilisation du capital[12].

2.2.5 Le secteur bancaire

Dans ce modèle, le secteur bancaire affecte l'équilibre macroéconomique à travers le taux d'intérêt des prêts, il se compose d'une infinité de banque b et d'un intermédiaire financier. La banque représentative $b \in [0,1]$ du pays i opère en concurrence monopolistique. Elle offre une quantité $L_{i,t+1}^s(b)$ de prêts en les finançant par des prêts à la banque centrale (facturés au taux directeur R_t). Un intermédiaire financier agrège toutes les variétés de prêts b pour les revendre aux entrepreneurs domestiques et étrangers de façon concurrentielle[13]. L'espérance que les clients remboursent, $\eta_{i,t+1}$, se calcule comme une moyenne arithmétique de ses clients domestiques et étrangers tels que $\eta_{i,t+1} = (1-\alpha_i^L)\eta_{h,t+1}^E + \alpha_i^L \eta_{f,t+1}^E$, où $\eta_{i,t+1}^E$ est la probabilité de remboursement des entrepreneurs du pays i. On peut alors écrire le profit espéré de la banque:

$$E_t \Pi_{i,t+1}^B(b) = E_t \eta_{i,t+1} R_{i,t}^L(b) L_{i,t+1}^s(b) - R_t L_{i,t+1}^s(b).$$

[12]Comme Christiano et al. (2005), cette fonction est de la forme $\Phi(u_{i,t+1}) \simeq \bar{Z}(u_{i,t+1}-1) + \frac{\bar{Z}\psi_i}{2}(u_{i,t+1}-1)^2$ et sa dérivée en logs s'écrit $\Phi'(\hat{u}_{i,t+1}) \simeq \frac{\psi_i}{1-\psi_i}\hat{u}_{i,t+1}$, où $\psi_i \in [0;1]$ est l'élasticité des coûts d'utilisation du capital par rapport à sa productivité marginale.

[13]Cet intermédiaire financier maximise les profits, $R_{i,t}^L L_{i,t+1} - \int_0^1 R_{i,t}^L(b) L_{i,t+1}^s(b) db$, sous contrainte de production $L_{i,t+1} = (\int_0^1 L_{i,t+1}^s(b)^{1/\mu_{i,t}^L} db)^{\mu_{i,t}^L}$. Les fonctions de demande pour prêts s'écrivent alors, $L_{i,t+1}^s(b) = (R_{i,t}^L(i)/R_{i,t}^L)^{-\mu_{i,t}^L/(\mu_{i,t}^L-1)} L_{i,t+1}, \forall b$. où $L_{i,t+1}$ est la demande agrégée de prêts aux banques du pays i.

Dans un premier temps, chaque banque maximise son profit en choisissant $L^s_{i,t+1}(b)$. Alors la condition du premier ordre définissant le coût marginal d'une unité de prêts s'écrit, $MC^L_{i,t}(b) = MC^L_{i,t} = R_t/E_t\eta_{i,t+1}$. Selon cette relation, une hausse de la probabilité de survie des entrepreneurs diminue le taux d'intérêt tandis qu'il augmente avec le taux directeur de la BCE[14].

En présence de rigidités nominales sur les taux d'intérêts, on suppose qu'une fraction θ^L_i de banques ne peut changer optimalement son taux d'intérêt, il évolue alors selon $R^L_{i,t}(b) = \left(R^L_{i,t-1}/R^L_{i,t-2}\right)^{\xi^L_i} R^L_{i,t-1}(b)$ en s'indexant sur sa variation précédente à un degré ξ^L_i. La part de banques $1-\theta^L_i$ qui peut choisir optimalement leur taux optimal $R^{L*}_{i,t}(b)$, maximise la somme suivante de profits:

$$\max_{\left\{R^{L*}_{i,t}(b)\right\}} E_t\left\{\sum_{\tau=0}^{\infty}\left(\theta^L_i\beta\right)^{\tau}\frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}}\left[\left(1-\tau^B\right)R^{L*}_{i,t}(b)\left(\frac{R^L_{i,t+\tau-1}}{R^L_{i,t-1}}\right)^{\xi^L_i} - MC^L_{i,t+\tau}\right]L_{i,t+1+\tau}(b)\right\}, \tag{2.24}$$

sous contrainte:

$$L_{i,t+1+\tau}(b) = \left(\frac{R^{L*}_{i,t}(b)}{R^L_{i,t+\tau}}\left(\frac{R^L_{i,t+\tau-1}}{R^L_{i,t-1}}\right)^{\xi^L_i}\right)^{-\mu^L_{i,t+\tau}/\left(\mu^L_{i,t+\tau}-1\right)} L_{i,t+1+\tau}, \forall\tau > 0. \tag{2.25}$$

Dans cette expression, $L_{i,t}(b)$ est la quantité de prêts bancaires demandée auprès de la banque b, $\mu^L_{i,t} = \bar{\mu}^L + \varepsilon^L_{i,t}$ est la marge des banques dont $\bar{\mu}^L$ est sa valeur stationnaire et $\varepsilon^L_{i,t}$ est la part exogène (suivant un processus $AR(1)$). Pour simplifier le problème, on suppose que le gouvernement taxe les distorsions de prix de long terme générées par la concurrence monopolistique au taux $\tau^B = 1-\mu^L$. La condition du premier ordre résolvant le problème précédent est:

$$\sum_{\tau=0}^{\infty}\left(\theta^L_i\beta\right)^{\tau}\frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}}\frac{L_{i,t+1+\tau}(b)}{\left(\mu^L_{i,t+\tau}-1\right)}\left[R^{L*}_{i,t}(b)\left(\frac{R^L_{i,t+\tau-1}}{R^L_{i,t-1}}\right)^{\xi^L_i} - \frac{\mu^L_{i,t+\tau}}{\left(1-\tau^B\right)}MC^L_{i,t+\tau}\right] = 0 \tag{2.26}$$

La rigidité introduite dans la fixation des taux d'intérêts sert essentiellement à intégrer de l'hétérogénéité dans la réponse des systèmes bancaires domestique et étranger. Plus précisément, ξ^L_i capte de la persistance dans les mouvements des taux du crédit du pays i. Pour le paramètre θ^L_i, il capture une rigidité dans la réponse des taux de crédit des banques du pays i aux changements du coût marginal des prêts domestiques et étrangers. Ces deux paramètres sont estimés sur les données bancaires dans la partie suivante.

[14]En logs ce coût marginal s'écrit, $mc^L_{i,t} = \kappa\overline{N/K}(1-\overline{N/K})^{-1}(\left(1-\alpha^L_i\right)(1-\varkappa_h)\frac{Q_{h,t}K_{h,t+1}}{N_{h,t+1}}/+\alpha^L_i(1-\varkappa_f)\frac{Q_{f,t}K_{f,t+1}}{N_{f,t+1}}) + r_t$. Il dépend du ratio du capital sur la richesse nette, $Q_{i,t}K_{i,t}/N_{i,t}$, des entrepreneurs domestiques et étrangers dans une proportion $1-\alpha^L_i$ et α^L_i.

2.3 Les autorités

Les gouvernements nationaux financent leurs dépenses publiques $P_{i,t}G_{i,t}$ par des taxes aux ménages, aux producteurs finaux, aux syndicats, aux banques et aux entrepreneurs. On suppose que les dépenses suivent un processus exogène $AR(1)$ tel que $G_{i,t} = \bar{G}e^{\varepsilon^G_{i,t}}$ comme Smets & Wouters (2007). La contrainte s'écrit:

$$\begin{aligned} P_{i,t}G_{i,t} = \tau^Y \int_0^1 P_{i,t}\left(i\right) Y_{i,t}\left(i\right) \mathrm{d}i + \tau^W \int_0^1 W_{i,t}\left(j\right) H_{i,t}\left(j\right) \mathrm{d}j \\ + \tau^L \int_0^1 L^s_{i,t+1}\left(b\right) R^L_{i,t}\left(b\right) \mathrm{d}b + \tau^E \int_0^1 P^C_{i,t} N^E_{i,t}\left(e\right) \mathrm{d}e \end{aligned} \tag{2.27}$$

La banque centrale européenne suit une règle de Taylor standard:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho^R} \left[\left(\pi^C_{h,t}\pi^C_{f,t}\right)^{\phi^\pi} \left(\frac{Y_{h,t}Y_{f,t}}{Y_{h,t-1}Y_{f,t-1}}\right)^{\phi^{\Delta y}}\right]^{\frac{1}{2}(1-\rho^r)} e^{\eta^R_t}, \tag{2.28}$$

où η^R_t est un terme d'erreur normal indépendant et identiquement distribué affectant de façon exogène la politique monétaire, ϕ^π est le paramètre de ciblage de l'inflation des prix à la consommation (l'indice des prix ciblé est la moyenne de l'inflation à la consommation domestique $\pi^c_{h,t}$ et étrangère $\pi^c_{f,t}$) tandis que $\phi^{\Delta y}$ est la cible de croissance du revenu visé par l'autorité monétaire.

2.4 Équilibre Général

Après avoir (i) agrégé l'ensemble des variétés, (ii) posé les hypothèses standards de pays miroirs[15] et d'apurement de l'ensemble des marchés, (iii) substitué les fonctions de demandes, la contrainte de ressources de l'économie domestique h s'écrit:

$$\begin{aligned} \frac{Y_{h,t}}{\Delta^P_{h,t}} = \left(1-\alpha^C\right)\left(\frac{P_{h,t}}{P^C_{h,t}}\right)^{-\mu} C_{h,t} + \alpha^C \left(\frac{P_{h,t}}{P^C_{f,t}}\right)^{-\mu} C_{f,t} \\ + \left(1-\alpha^I\right)\left(\frac{P_{h,t}}{P^I_{h,t}}\right)^{-\mu} \left(1+AC^I_{h,t}\right) I_{h,t} + \alpha^I \left(\frac{P_{h,t}}{P^I_{f,t}}\right)^{-\mu} \left(1+AC^I_{f,t}\right) I_{f,t} \\ + AC^B_{h,t} + \left(1-\eta_{h,t}\right) \underline{\omega}_{h,t} Q_{h,t} K^u_{h,t} + \Phi\left(u_{h,t}\right) K_{h,t-1} + \bar{G}e^{\varepsilon^G_{i,t}} \end{aligned} \tag{2.29}$$

où $\Delta^P_{i,t} = \int_0^1 (P_{i,t}(i)/P_{i,t})^{-\epsilon_P} \mathrm{d}i$ est la dispersion des prix. Les rigidités nominales sur ce marché font que les prix agrégés évoluent selon:

$$P^{1-\epsilon_P}_{i,t} = \theta^P_i \left(P_{i,t-1}\pi^{\xi^P_i}_{i,t-1}\right)^{1-\epsilon_P} + \left(1-\theta^P_i\right)\left(P^*_{i,t}\right)^{1-\epsilon_P}. \tag{2.30}$$

[15] L'hypothèse de pays miroirs suppose que les deux pays ont les mêmes taux d'ouverture, $\alpha^s_h = \alpha^s \Leftrightarrow \alpha^s_f = (1-\alpha^s), \forall s \in \{C, I, L\}$, et que les pays sont de taille similaire.

L'agrégation des syndicats en mesure de changer ou non leurs salaires implique que les salaires agrégés suivent:

$$W_{i,t}^{1-\epsilon_W} = \theta_i^W (W_{i,t-1} \left(\pi_{i,t-1}^C\right)^{\xi_i^W})^{1-\epsilon_W} + \left(1-\theta_i^W\right) \left(W_{i,t}^*\right)^{1-\epsilon_W}. \tag{2.31}$$

L'agrégation des taux d'intérêt suppose que:

$$\left(R_{i,t}^L\right)^{\frac{1}{1-\mu_{i,t}^L}} = \theta_i^L \left(R_{i,t-1}^L \left(\frac{R_{i,t-1}^L}{R_{i,t-2}^L} \right)^{\xi_i^L} \right)^{\frac{1}{1-\mu_{i,t}^L}} + \left(1-\theta_i^L\right) \left(R_{i,t}^L\right)^{\frac{1}{1-\mu_{i,t}^L}}, \tag{2.32}$$

tandis que l'équilibre sur le marché du crédit domestique s'écrit:

$$L_{h,t+1}^s = \left(\left(1-\alpha^L\right) \left[\frac{R_{h,t}^L}{P_{h,t}^L}\right]^{-\nu} L_{h,t+1}^d + \alpha^L \left[\frac{R_{h,t}^L}{P_{f,t}^L}\right]^{-\nu} L_{f,t+1}^d \right) \Delta_{h,t}^L, \tag{2.33}$$

où $\Delta_{h,t}^L$ est la dispersion des taux du crédit. L'équilibre des marchés financiers et du marché de l'épargne sont définis par, $CA_{h,t} + CA_{f,t} = 0$ et $B_{h,t+1} + B_{f,t+1} = 0$. Le solde du compte courant de l'économie domestique h s'écrit:

$$CA_{h,t} = (B_{h,t+1} - B_{h,t}) + [(L_{h,f,t+1} - L_{h,f,t}) - (L_{f,h,t+1} - L_{f,h,t})] \tag{2.34}$$

Enfin, le modèle se compose de six chocs structurels par pays $i \in \{h, f\}$ et un choc sur la règle monétaire[16]. Les 13 chocs suivent un processus autorégressif de la forme, $\varepsilon_{i,t}^s = \rho_i^s \varepsilon_{i,t-1}^s + \eta_{i,t}^s$, $\forall s = \{U, A, G, Q, N, L\}$. L'ensemble de ces chocs $AR(1)$ ont comme racines les paramètres ρ_i^U, ρ_i^A, ρ_i^G, ρ_i^Q, ρ_i^N, ρ_i^L et ρ^R et comme termes d'erreur $\eta_{i,t}^U$, $\eta_{i,t}^A$, $\eta_{i,t}^G$, $\eta_{i,t}^Q$, $\eta_{i,t}^N$, $\eta_{i,t}^L$ et η_t^R mutuellement indépendants, non corrélés et normalement distribués de moyenne nulle et de variance $\sigma_{i,U}^2$, $\sigma_{i,A}^2$, $\sigma_{i,G}^2$, $\sigma_{i,Q}^2$, $\sigma_{i,N}^2$, $\sigma_{i,L}^2$ et σ_R^2.

3 Estimation des paramètres du modèle

Dans cette section nous estimons le modèle précédent en utilisant l'économétrie bayésienne[17] pour les deux principales économies de la zone euro : l'Allemagne et la France[18]. Le

[16] Nous avons précisément 13 chocs car nous estimons dans la partie suivante le modèle sur 13 séries temporelles. Pour éviter le problème de singularité stochastique, nous devons avoir au moins autant de chocs que de séries temporelles. Le choix de ces chocs sont principalement inspirés des travaux de Smets et Wouters pour la partie réelle, et de Hirakata *et al.* (2012) pour la partie financière. Nous les avons choisi de telle sorte que le modèle colle au mieux aux données.

[17] Cette méthode s'est imposée à la suite des travaux de Smets & Wouters (2003). Ils montrent qu'un modèle *DSGE* avec suffisamment de paramètres estimables, de chocs et de rigidités est capable d'expliquer les fluctuations macroéconomiques de la zone euro aussi bien qu'un VAR non contraint. D'autres raisons justifient l'emploi de l'inférence bayésienne, les principales sont que les modèles *DSGE* sont mal spécifiés et l'information contenue dans les données est insuffisante, l'ajout de croyances pallie ces carences informationnelles.

[18] Ces deux pays représentent 49% du PIB de la zone Euro et 45% de la population et présentent pour intérêt d'être à la fois importateurs et exportateurs de prêts bancaires.

modèle est estimé en log déviation à partir d'un état stationnaire symétrique. Nous calibrons les paramètres de long terme de l'économie de façon standard par rapport à la littérature des cycles réels : le taux de dépréciation du capital $\delta = 0.025$, le facteur d'actualisation $\beta = 0.99$, la part du capital dans la production $\alpha = 0.36$, la part des dépenses publiques dans le revenu $\overline{G/Y} = 0.2$ et les coûts d'ajustement sur l'épargne $\chi^B = 0.07\%$. On approxime le degré d'ouverture intrazone $\alpha^C = 0.0922$ et $\alpha^I = 0.0439$ en utilisant les calculs de Eyquem & Poutineau (2010). Du côté financier, on fixe le ratio des capitaux sur l'autofinancement à $\overline{K/N} = 1/0.275$ en suivant Gerali et al. (2010), tandis que le spread entre le taux des prêts bancaires par rapport à celui du refinancement $\overline{R}^L - \overline{R} = 0.0210^{0,25}$ est de 210 points de base annuels en moyenne pour la France et l'Allemagne, ce qui est proche de Faia (2007) et Hirakata et al. (2009)[19]. Du côté de la distribution de Pareto, on a $\omega \in [\omega_{\min}; +\infty[$, $\omega \sim \mathcal{P}(\kappa; \omega_{\min})$ où κ (paramètre de forme) et $\omega_{\min}$ sont déterminés par $\omega_{\min} = (\kappa - 1)/\kappa = 1 - \overline{N/K}$, plus de détails sur la distribution de Pareto sont donnés en annexe de la thèse (subsubsection 1.5.2 page 185).

Les paramètres qui affectent les dynamiques conjoncturelles sont estimées sur la période 2003T1 à 2012T4 à l'aide de 13 séries temporelles[20]. Les données avec une tendance sont rendues stationnaires en utilisant un trend linéaire et en exprimant les données par tête. Les croyances *a priori* présentées dans la Table 2.1 sont proches de celles utilisées communément dans la littérature. En particulier, pour σ_i^C, σ_i^L, h_i^C, θ_i^P, ξ_i^P, ξ_i^W, χ_i^I, ψ_i, ϕ^π, $\phi^{\Delta y}$ et les paramètres des processus de choc nous suivons Smets & Wouters (2003, 2007). Le taux d'ouverture du marche bancaire α^L a une croyance peu informative avec une distribution Beta de moyenne $0,5$ et d'écart type $0,15$. Pour la rigidité des taux d'intérêt, nos croyances sont les mêmes que les prix à la Calvo. Enfin pour l'élasticité de la prime de financement externe $\varkappa_i$, nous utilisons une distribution normale de moyenne $0,1$ et d'écart type $0,05$ ce qui est moins informatif que Gilchrist, Ortiz, & Zakrajsek (2009) et la littérature de l'accélérateur financier en général.

Le vecteur θ des paramètres du modèle présenté dans la Section 2 est estimé sous deux restrictions : soit le marché bancaire est segmenté ($\mathcal{M}_1(\theta)$ avec $\alpha^L = 0$, $\nu = 0$), soit il est intégré ($\mathcal{M}_2(\theta)$ avec $\alpha^L \in [0,1]$ et $\nu > 0$). La confrontation du modèle aux données permet de réviser les probabilités *a priori* afin d'obtenir celles *a posteriori*. La distribution *a posteriori* combine la fonction de vraisemblance des informations *a*

[19] Cette calibration donne un taux d'échec des projets d'investissement de 1.8% ce qui est comparable à Bernanke et al. (1999).

[20] Produit intérieur brut, dépenses de consommation finale privée, formation brut de capital fixe, déflateur du produit intérieur brut: approche par les dépenses, en millions de monnaie nationale, prix courants, niveaux trimestriels, données désaisonnalisées - sources OECD stats. Prêts aux entreprises (toutes échéances, zone euro, les sociétés non financières S.11), taux d'intérêt des banques (Credit et autres institutions; Prêts à maturité d'un an) - sources ECB. Taux de Refinancement BCE: les taux d'intérêt des banques centrales, un an maturité, données trimestrielles - sources Eurostat.

priori, elle se calcule par l'algorithme Metropolis-Hastings qui en évalue la vraisemblance marginale[21]. Le modèle $\mathcal{M}_2(\theta)$ a un meilleur pouvoir explicatif, sa vraisemblance marginale (-659.38) étant plus grande que celle de $\mathcal{M}_1(\theta)$ (-662,72). Enfin, pour le test de significativité des flux transfrontaliers, nous testons $H_0 : \alpha^L = 0,\ \nu = 0$ contre $H_1 : \alpha^L \in [0,1],\ \nu > 0$, à partir du rapport des cotes *a posteriori* de $\mathcal{M}_2(\theta)$ sur $\mathcal{M}_1(\theta)$[22]. Les probabilités *a posteriori* de l'hypothèse nulle de non-importance des flux bancaires étant de 28:1 nous rejetons l'hypothèse nulle.

Les différences ou similitudes entre les paramètres estimés dans la Table 2.1 pour la France et l'Allemagne permettent de préciser l'origine microéconomique des asymétries entre ces deux pays. L'aversion au risque et les habitudes de consommation sont plus élevées chez les ménages français tandis la désutilité liée au travail est la même entre ces deux pays. En outre, la moyenne *a posteriori* de durée des contrats de prix est d'environ 8 mois. L'Allemagne présente des rigidités nominales fortes sur les prix, salaires et taux de crédit tandis que la France a des frictions réelles plus importantes, en particulier sur le coût d'ajustement de l'investissement et les habitudes de consommation. Du côté de l'appareil productif, la France a un appareil plus rigide que l'Allemagne du fait que le coût d'utilisation du capital y est plus grand. L'élasticité de la prime de financement externe est quasiment égale entre investisseurs français et allemands, même si les investisseurs outre-Rhin semblent légèrement plus optimistes. Cette estimation de la prime de financement externe est plus élevée que celles pour les USA de Gilchrist, Ortiz, & Zakrajsek (2009) et de De Graeve (2008).

[21]Pour obtenir la distribution *a posteriori*, un échantillon de 250 000 tirages a été généré, en omettant les premiers 50 000. Le facteur d'échelle a été choisi afin d'obtenir un taux d'acceptation entre 20 et 30 pourcents.

[22]Pour cela, on pose une croyance identique sur chaque modèle. On calcule ensuite le rapport des cotes via une approximation de Laplace de la densité marginale des données.

		Distributions. *a priori*			Distributions *a posteriori* de $\mathcal{M}_1$ *[5%:95%]*				Distributions *a posteriori* de $\mathcal{M}_2$ *[5%:95%]*			
		Forme	Moyenne	Std.	ALLEMAGNE		FRANCE		ALLEMAGNE		FRANCE	
Productivité std.	σ_i^A	invGam	0.1	2	1.13	*[0.60:1.61]*	0.68	*[0.34:1.00]*	1.20	*[0.70:1.74]*	0.75	*[0.37:1.08]*
Dépenses Pub. std.	σ_i^G	invGam	0.1	2	2.51	*[2.02:2.99]*	1.19	*[0.94:1.43]*	2.51	*[2.02:2.97]*	1.16	*[0.93:1.39]*
Préferences std.	σ_i^U	invGam	0.1	2	1.06	*[0.58:1.45]*	1.04	*[0.71:1.39]*	1.08	*[0.61:1.57]*	1.02	*[0.67:1.38]*
Richesse Nette std.	σ_i^N	invGam	0.1	2	0.27	*[0.20:0.34]*	0.14	*[0.10:0.18]*	0.28	*[0.20:0.36]*	0.17	*[0.12:0.22]*
Prime de Fi. Externe std.	σ_i^Q	invGam	0.1	2	0.81	*[0.59:1.04]*	0.92	*[0.69:1.16]*	0.92	*[0.65:1.19]*	1.17	*[0.85:1.49]*
Marge de taux d'intérêt std.	σ_i^L	invGam	0.1	2	0.09	*[0.06:0.12]*	0.10	*[0.06:0.13]*	0.09	*[0.06:0.12]*	0.10	*[0.06:0.13]*
Productivité AR(1) racine	ρ_i^A	Beta	0.85	0.1	0.98	*[0.95:1.00]*	0.97	*[0.93:1.00]*	0.98	*[0.93:1.00]*	0.98	*[0.95:1.00]*
Dépenses Pub. AR(1) racine	ρ_i^G	Beta	0.85	0.1	0.79	*[0.65:0.95]*	0.92	*[0.85:0.99]*	0.79	*[0.64:0.95]*	0.92	*[0.84:0.99]*
Preferences AR(1) racine	ρ_i^U	Beta	0.85	0.1	0.66	*[0.47:0.86]*	0.77	*[0.61:0.93]*	0.67	*[0.48:0.87]*	0.81	*[0.68:0.95]*
Richesse Nette AR(1) racine	ρ_i^N	Beta	0.85	0.1	0.94	*[0.90:0.99]*	0.96	*[0.92:0.99]*	0.95	*[0.91:0.99]*	0.95	*[0.91:0.99]*
Prime de Fi. Ext. AR(1) racine	ρ_i^Q	Beta	0.85	0.1	0.58	*[0.44:0.71]*	0.52	*[0.39:0.66]*	0.53	*[0.40:0.67]*	0.48	*[0.34:0.62]*
Marge de taux AR(1) racine	ρ_i^L	Beta	0.85	0.1	0.57	*[0.42:0.74]*	0.62	*[0.47:0.78]*	0.58	*[0.42:0.73]*	0.60	*[0.44:0.75]*
Aversion au Risque	σ_i^C	Normal	1	0.375	1.56	*[1.13:1.98]*	1.67	*[1.24:2.08]*	1.61	*[1.17:2.05]*	1.66	*[1.24:2.10]*
Habitude de Consommation	h_i^C	Beta	0.7	0.1	0.49	*[0.34:0.65]*	0.69	*[0.55:0.85]*	0.50	*[0.34:0.65]*	0.68	*[0.55:0.83]*
Désutilité du Travail	σ_i^L	Gamma	2	0.5	3.44	*[1.87:4.88]*	3.44	*[1.80:4.98]*	3.53	*[1.90:5.08]*	3.24	*[1.70:4.78]*
Prix à la Calvo	θ_i^P	Beta	0.75	0.05	0.70	*[0.60:0.81]*	0.63	*[0.49:0.76]*	0.71	*[0.63:0.80]*	0.65	*[0.52:0.78]*
Indexation des Prix	ξ_i^P	Beta	0.5	0.15	0.10	*[0.03:0.16]*	0.10	*[0.03:0.16]*	0.11	*[0.04:0.17]*	0.10	*[0.03:0.17]*
Salaires à la Calvo	θ_i^W	Beta	0.75	0.05	0.77	*[0.68:0.86]*	0.77	*[0.68:0.86]*	0.77	*[0.68:0.86]*	0.77	*[0.68:0.86]*
Indexation Salaires	ξ_i^W	Beta	0.5	0.15	0.45	*[0.20:0.69]*	0.43	*[0.20:0.68]*	0.46	*[0.22:0.71]*	0.44	*[0.20:0.69]*
Taux de Crédit à la Calvo	θ_i^L	Beta	0.5	0.1	0.77	*[0.70:0.84]*	0.69	*[0.60:0.78]*	0.76	*[0.68:0.84]*	0.72	*[0.63:0.82]*
Indexation des taux	ξ_i^b	Beta	0.5	0.15	0.64	*[0.42:0.86]*	0.59	*[0.36:0.83]*	0.67	*[0.47:0.88]*	0.61	*[0.38:0.85]*
Coût d'Ajustement de l'Invest.	χ_i^I	Normal	4	1.5	0.84	*[0.53:1.16]*	2.47	*[1.56:3.36]*	1.09	*[0.63:1.57]*	3.22	*[2.02:4.42]*
Utilisation du Capital	ψ_i	Beta	0.5	0.05	0.52	*[0.44:0.60]*	0.60	*[0.53:0.68]*	0.53	*[0.45:0.62]*	0.61	*[0.54:0.68]*
Elasticité Prime de Fi. Externe	$\varkappa_i$	normal	0.1	0.05	0.07	*[0.02:0.13]*	0.07	*[0.01:0.11]*	0.08	*[0.01:0.14]*	0.07	*[0.01:0.13]*
Habitude de Prêts	h_i^L	Beta	0.7	0.1	0.83	*[0.74:0.91]*	0.84	*[0.77:0.92]*	0.82	*[0.73:0.90]*	0.85	*[0.77:0.92]*
Taux BCE std	σ^R	invGam	0.1%	2		0.10	*[0.08:0.12]*			0.10	*[0.08:0.12]*	
Taux BCE AR(1) racine	ρ^R	Beta	0.7	0.1		0.76	*[0.70:0.837]*			0.77	*[0.71:0.83]*	
Cible BCE sur l'Inflation	ϕ^π	Normal	2	0.25		1.61	*[1.21:2.06]*			1.60	*[1.15:2.16]*	
Cible BCE sur le PIB	$\phi^{\Delta y}$	Normal	0.125	0.05		0.17	*[0.09:0.24]*			0.17	*[0.10:0.24]*	
Ouverture Bancaire	α^L	Beta	0.5	0.15			-			0.22	*[0.16:0.27]*	
Substitution biens finals	μ	Gamma	1	0.2		1.38	*[1.01:1.75]*			1.46	*[1.09:1.83]*	
Substitution Prêts	ν	Gamma	1	0.2			-			0.93	*[0.63:1.24]*	
Log-Vraisemblance Marginale							-662.72				-659.38	

TABLE 2.1: Distributions des croyances *a priori* et des *a posteriori* des paramètres structurels et des processus de choc

4 Effets macroéconomiques des prêts transfrontaliers

4.1 Les conséquences de chocs réel et financier asymétriques

La première partie de la Figure 2.3 présente la transmission d'un choc de productivité asymétrique positif affectant l'économie allemande ($\varepsilon^{A}_{h,t}$) à l'aide des fonctions de réponse impulsionnelles (IRFs, dans ce qui suit) bayésiennes. Lorsque les marchés des prêts sont segmentés (ligne pointillée), le choc de productivité augmente la production, la consommation et l'investissement, tout en diminuant le taux d'inflation dans l'économie allemande. Comme dans les travaux de Smets & Wouters (2003, 2007), la transmission de ce choc à l'économie française s'effectue par le biais des termes de l'échange, du compte courant et de la réaction du taux d'intérêt directeur de la banque centrale : la détérioration des termes de l'échange accroît la compétitivité relative des produits allemands et leurs exportations. Dans le même temps, une partie de la hausse de la consommation intérieure allemande va avoir des répercutions sur la demande de biens français et créer des tensions inflationnistes. Comme la baisse de l'inflation allemande est supérieure à la hausse des prix des biens français, l'inflation moyenne de la zone euro diminue, ce qui conduit la banque centrale à réduire le taux d'intérêt interbancaire. En ce qui concerne l'aspect financier du modèle, le ratio d'endettement ($Q_{i,t}K_{i,t}/N_{i,t}$) augmente dans les deux pays. Comme le capital devient plus productif dans l'économie allemande, les entreprises investissent plus, ce qui augmente leur demande de prêts dans ce pays. Ces résultats sont standards avec la littérature de l'accélérateur financier (Bailliu et al., 2012). Le taux d'intérêt sur les prêts est entraîné par l'effet de levier des entrepreneurs et le taux interbancaire. La réduction du taux d'intérêt interbancaire diminue dans un premier temps les taux d'intérêt sur les indices de crédit nationaux et étrangers. Cependant, comme l'endettement augmente, cela tend à accroître la faillite des projets d'investissement dans les deux pays et de la même façon, le taux d'intérêt servi par les banques augmente après 5 trimestres. En outre, les cycles du crédit sont étroitement liés aux cycles du capital, c'est pour cette raison qu'il faut au crédit 80 périodes pour revenir à son état stationnaire.

Les prêts transfrontaliers (ligne pleine) agissent comme un mécanisme qui augmente l'activité globale de l'union monétaire. L'ouverture bancaire dégrade la performance macroéconomique de l'économie française car l'offre de crédit nationale est en partie détournée vers l'économie allemande. Enfin, la dynamique du compte courant se trouve elle aussi affectée par les prêts transfrontaliers. En autarcie bancaire, l'ajustement du compte courant est standard au sens où l'économie allemande connaît un excédent des exportations nettes à la suite du choc de productivité domestique. En tenant compte des prêts transfrontaliers, son compte courant se détériore clairement après 5 trimestres car cette économie rembourse les intérêts sur les prêts contractés auprès des banques françaises.

La seconde partie de la Figure 2.3 reporte les IRFs faisant suite à un choc négatif affectant la richesse nette des entreprises allemandes ($\varepsilon^N_{h,t}$), suivant par exemple une chute de la bourse. En l'absence de prêts transfrontaliers (ligne pointillée), ce choc induit une réduction de l'activité (tirée par la chute de l'investissement) et une déflation en Allemagne. La banque centrale réagit à la déflation en réduisant son taux d'intérêt interbancaire, ce qui soutient la consommation et amortit l'impact du choc sur l'investissement. Comme l'investissement diminue plus que l'activité, la consommation augmente. De plus, comme la déflation est plus forte dans l'économie allemande que dans l'économie française, les termes de l'échange allemands se détériorent ce qui améliore les exportations de cette économie et le solde de son compte courant. L'économie française est affectée par le choc allemand à travers la réduction du taux d'intérêt directeur et à travers les termes de l'échange. La baisse du taux directeur réduit l'indice du taux du crédit étranger. Ainsi, bien que sa situation se soit détériorée, l'économie étrangère bénéficie de la réduction du taux d'intérêt interbancaire. En particulier, l'augmentation de la consommation étrangère doit être reliée à l'amélioration des termes de l'échange nationaux qui permet à cette économie d'acheter moins cher des biens étrangers.

Les flux bancaires transfrontaliers (ligne pleine) amplifient la transmission de ce choc financier dans la zone euro. Comme les firmes domestiques ont accès au secteur bancaire étranger, elles bénéficient dans un premier temps de conditions d'emprunt plus avantageuses. Cela soutient la demande de crédit domestique, conduit à une augmentation du montant des crédits distribués par les banques étrangères et augmente l'effet de levier pour les firmes domestiques. A l'inverse, les firmes étrangères font face à des conditions d'emprunt qui se sont détériorées, puisque le secteur bancaire étranger propose des prêts à des taux plus élevés. Ce phénomène réduit l'effet de levier et l'investissement dans l'économie étrangère. L'investissement total de la zone baisse, ce qui renforce la réduction de l'activité dans les deux pays par rapport à la situation de segmentation bancaire. Ainsi, les flux transfrontaliers constituent un mécanisme d'amplification lors de la transmission de choc financier négatif. Ce résultat est en accord avec ceux obtenus par (Ueda, 2012) et (Hirakata et al., 2011). De ce fait, la banque centrale doit être en mesure de réagir plus fortement à ce type de choc en présence d'échanges bancaires transfrontaliers. Ainsi, au cours des 30 trimestres représentés dans les IRFs, la croissance de l'activité de la zone est 17% inférieure à la situation de segmentation nationale du marché des prêts.

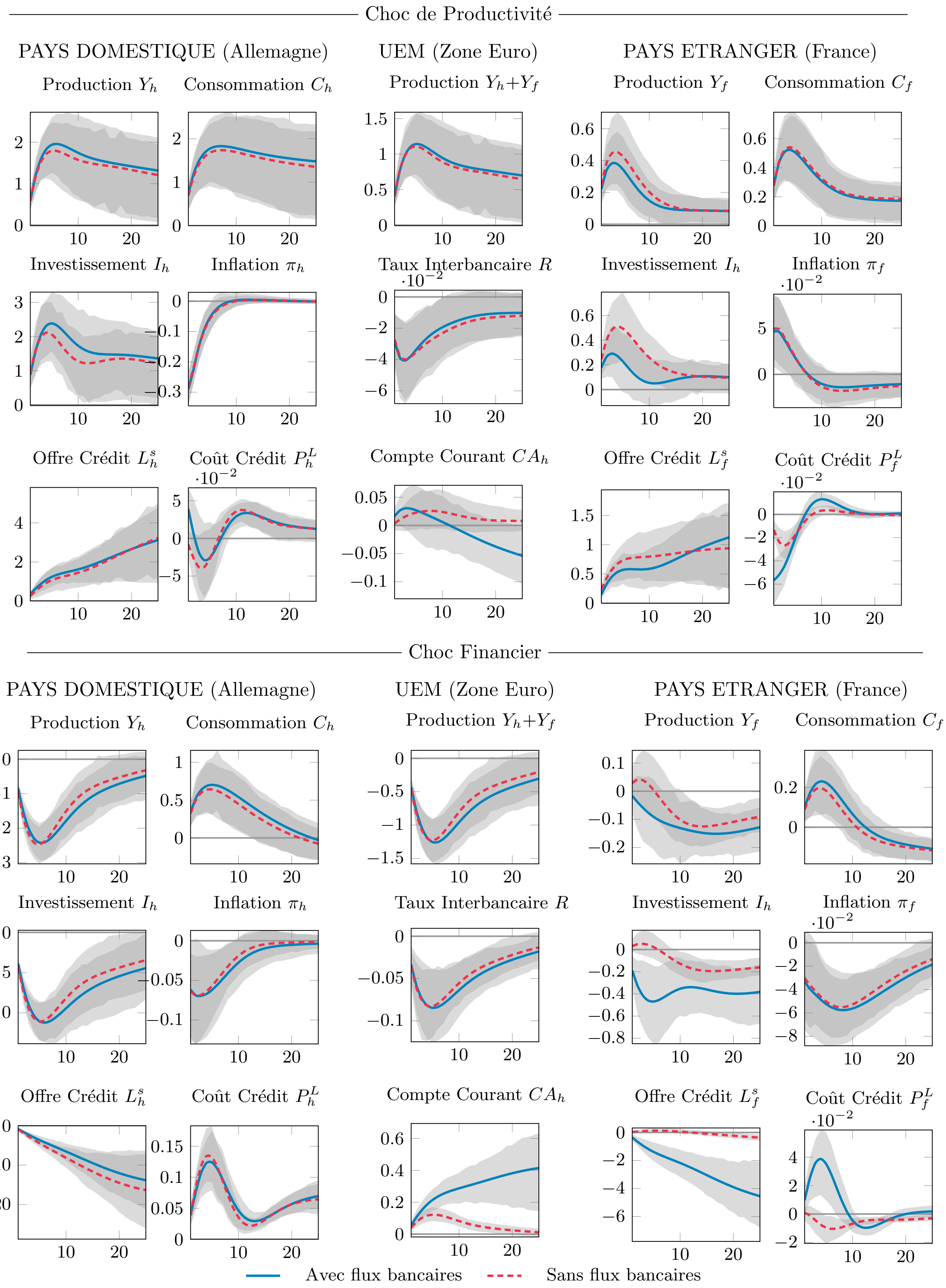


FIGURE 2.3: IRF bayésienne des modèles $\mathcal{M}_2$ avec prêts transfrontaliers (en ligne pleine) et $\mathcal{M}_1$ sans (en pointillés) suite à un choc positif de productivité et de destruction d'actifs financiers en Allemagne

4.2 La décomposition de la variance

La Table 2.2 présente de la décomposition de la variance *a posteriori* des principales variables[23] des modèles $\mathcal{M}_1$ et $\mathcal{M}_2$. En tenant compte des flux bancaires transfrontaliers (première partie du tableau) on peut remarquer la dominance des chocs d'offre sur la variance de l'investissement et la consommation. L'investissement, l'offre de prêt et le coût du crédit sont principalement expliqués par les chocs financiers domestiques. Ces résultats correspondent à l'analyse de Hirakata et al. (2011) pour les USA. En contraste, les chocs de demande (dépenses publiques et préférences) ont un rôle négligeable sur toutes les variables. En outre, le modèle capte les hétérogénéités entre les deux économies: les chocs financiers (de richesse nette ou de prime de financement externe) ont un impact plus important sur l'Allemagne que sur la France. La variable reflétant plus l'hétérogénéité est l'investissement: la contribution des chocs d'offre est plus grande en France (27,4%) qu'en Allemagne (17,1%), à l'inverse des chocs financiers relativement plus importants en Allemagne (81,2%) qu'en France (69,2%). Concernant la diffusion des chocs entre pays, la France apparaît plus affectée que l'Allemagne. Pour s'en convaincre, la contribution du choc de richesse nette français représente 6,28% de la variance de l'offre de prêt allemand, alors que les chocs allemands expliquent 22,7% de la variance du volume de crédit français. Ces résultats se retrouvent aussi sur les chocs d'offre. Concernant la politique monétaire, les chocs allemands représentent 60% de la variance du taux de refinancement de la BCE et du compte courant bilatéral. L'Allemagne semble donc mener les cycles de la zone euro.

Une comparaison des modèles $\mathcal{M}_2$ et $\mathcal{M}_1$ montre que la France est plus affectée par les transferts bancaires que l'Allemagne. Pour preuve, quand on ferme les frontières bancaires, la part de variance de l'offre de crédit français $var(L^s_{f,t})$ passe de 70% à 42,1% pour les chocs de richesse nette (72,3% à 64,3% pour l'Allemagne). L'impact sur les variables réelles reste relativement peu important, les effets les plus significatifs de l'ouverture bancaire s'observent sur les variables financières. Finalement, les prêts transfrontaliers semblent avoir affecté la conduite de la politique monétaire. On peut l'observer par l'augmentation de part des chocs financiers dans la contribution de la variance du taux de refinancement $var(R_t)$. La BCE serait donc plus sensible au stress financier quand il y a ouverture bancaire, comme l'a déjà montrée l'analyse des IRF bayésiennes. Comme présenté dans la Table 2.2, les chocs financiers cumulés représentent 46,7% avec intégration bancaire alors qu'ils représentaient 41,8% en autarcie, cela se fait au détriment des chocs d'offre (ils passent de 44.8% à 40,3%).

[23] Ces variables sont l'activité, la consommation, l'investissement, l'offre de crédit, l'indice de taux d'intérêt payé par les emprunteurs en Allemagne et en France, le compte courant Allemand et le taux d'intérêt de la BCE.

	Allemagne						France						Euro
	σ^A_{all}	σ^G_{all}	σ^U_{all}	σ^N_{all}	σ^Q_{all}	σ^L_{all}	σ^A_{fr}	σ^G_{fr}	σ^U_{fr}	σ^N_{fr}	σ^Q_{fr}	σ^L_{fr}	σ^R
Avec flux bancaires transfrontaliers $\mathcal{M}_2$													
$var(Y_{all})$	71.2	0.9	0.2	26.1	0.3	0.4	0.7	0	0	0.1	0	0	0.1
$var(I_{all})$	17.1	0.1	0	81.2	0.5	0.7	0.1	0	0	0.3	0	0	0
$var(L^s_{all})$	26.1	0.1	0	64.3	0.1	0.1	3	0	0	6.3	0	0	0
$var(Y_{fr})$	2.3	0	0	1	0	0	83.1	0.7	0.4	12	0.1	0.1	0.2
$var(I_{fr})$	0.5	0	0	2	0	0	27.4	0.1	0	69.2	0.4	0.3	0
$var(L^s_{fr})$	6.9	0	0	22.7	0	0	27.8	0.1	0	42.1	0.2	0.1	0
$var(CA_{all})$	14.6	0.1	0.1	47.1	0.1	0.1	13.7	0.1	0.2	23.7	0.1	0	0
$var(R_t)$	22.3	0.6	1.2	35.3	0.2	0.3	18	0.2	4.8	11.2	0	0.1	5.5
Sans flux bancaires transfrontaliers $\mathcal{M}_1$													
$var(Y_{all})$	68.7	1	0.2	28.1	0.4	0.6	0.8	0	0	0.1	0	0	0.1
$var(I_{all})$	15.2	0.1	0	82.7	0.7	1	0.2	0	0	0	0	0	0
$var(L^s_{all})$	26.6	0.1	0	72.6	0.1	0.1	0.3	0	0	0.1	0	0	0
$var(Y_{fr})$	4.1	0	0	1	0	0	75.8	1	0.7	16.9	0.1	0.1	0.3
$var(I_{fr})$	0.9	0	0	0.4	0	0	20.2	0.2	0	77.5	0.3	0.4	0
$var(L^s_{fr})$	2.1	0	0	1.3	0	0	26	0.2	0	70	0.2	0.1	0
$var(CA_{all})$	9.7	0.2	3.6	55.9	0.7	1	9	0.1	8.6	10.9	0.1	0.1	0.1
$var(R_t)$	23.6	0.7	1.3	33	0.3	0.5	21.2	0.3	4.4	8.4	0.1	0.1	6.2

TABLE 2.2: Décomposition de la variance inconditionnelle *a posteriori* en % : elle est la part en % de variance expliquée par chaque choc selon le modèle $\mathcal{M}_1$ (sans prêts transfrontaliers) et $\mathcal{M}_2$ (avec). CA_{all} est le compte courant allemand (sachant que $CA_{all} = -CA_{fr}$).

5 Conclusion

Cet article a étudié les conséquences macroéconomiques des prêts transfrontaliers à l'aide d'un modèle DSGE décrivant une union monétaire hétérogène à deux pays. Il a été estimé sur données allemandes et françaises entre le premier trimestre 2003 et le quatrième trimestre 2012. Les principaux résultats obtenus peuvent être résumés de la manière suivante: tout d'abord on a observé que ces flux transfrontaliers affectaient de manière significative la transmission internationale des chocs asymétriques réels et financiers et qu'ils modifiaient la contribution relative des chocs financiers et réels sur la variance des principales variables d'intérêt du modèle. Ce canal transfrontalier a eu plus d'impact sur la France que sur l'Allemagne et qu'il a renforcé la diffusion des chocs financiers entre les deux pays. Enfin, les variations du taux d'intérêt directeur de la BCE sont devenues plus sensibles aux chocs de nature financière aux dépends des chocs réels.Ces résultats militent pour la prise en compte de ce canal de diffusion des chocs au sein de l'UEM et conduisent à recommander la prise en compte de ce mécanisme dans l'étude des mesures de surveillance du secteur bancaire en Europe.

Chapter 3

Macroprudential Policy with Cross-border Corporate Loans: Granularity Matters

1 Introduction

Macroprudential policy is now considered as a necessary complement to monetary policy and microprudential supervision to manage systemic risks in the European Monetary Union (hereafter, EMU). Owing to the federal structure of the Eurozone, the institutional organization of this new policy is original with regards to other developed economies. As underlined by Loisel (2014), this group of countries has a single monetary authority (the European Central Bank), a common macroprudential authority (the European Systemic Risk Board, hereafter ESRB) and national macroprudential authorities. Currently, the choice of macroprudential conduct in the Eurozone is based on a granular scheme: supervisory and regulatory frameworks remain fragmented along national lines, while the coordination and internalization of cross-border spillovers are achieved at by the ESRB.

Beyond this institutional organization, the conduct of macroprudential measures in the Eurozone should account for two conflicting economic features. On the one side, as an integrated area, this set of countries should conduct federal macroprudential measures; on the other side, despite a deeper integration, financial cycles remain national, underlying the key role of a national conduct of macroprudential measures. This critical dichotomy can be approached by contrasting core countries and peripheral countries[1]. As reported in panel (a) of Figure 3.1 financial cycles (measured as the credit to GDP ratio in percentage deviation from HP trend) are more pronounced in peripheral countries, which militate for a decentralized definition and implementation of macroprudential measures. However, an unequal treatment of nations can be harmful given the increased cross-border banking activity (measured though cross-border bank lending as percentage of nominal GDP) reported in panel (b). Externalities coming from a national implementation of macroprudential measures could be dampened through a federal coordination scheme[2].

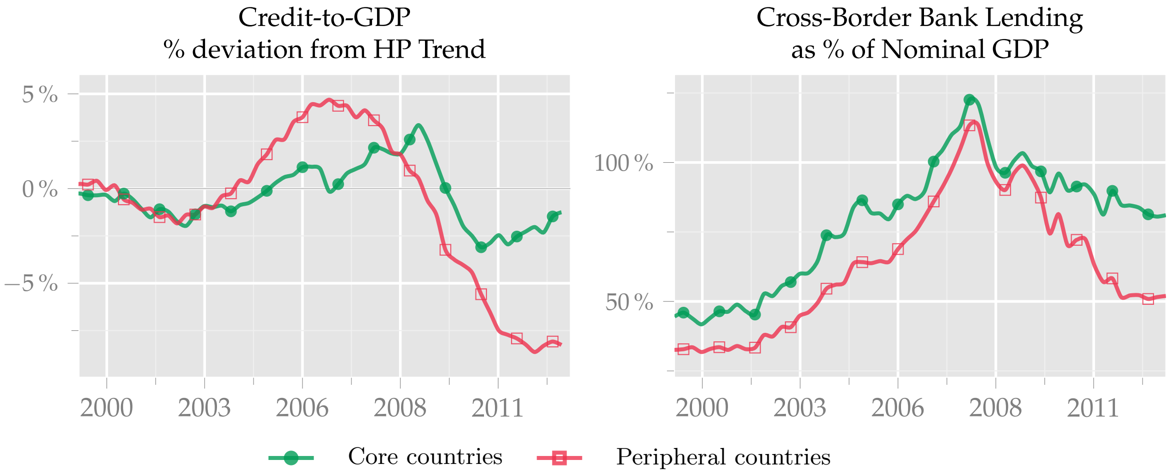


FIGURE 3.1: Stylized facts characterizing the Eurosystem banking system: credit cycles remain clearly national while cross-border lending experienced an explosive growth *(ESRB and BIS statistics).*

This chapter discusses how national and federal concerns should be balanced in the EMU though the choice in the degree of granularity of macroprudential actions. Two complementary dimensions are accounted for: should macroprudential policy react to national or federal financial developments? Should macroprudential parameters be imposed uniformly to all countries or tailored to the particular situation of each member?

In this chapter, we analyze countercyclical macroprudential policies. As in Fatas & et al. (2009), Quint & Rabanal (2013) and Bailliu et al. (2012), we introduce a macroprudential

[1]In the first group, we aggregate data for countries with a current account surplus over the sample period (Austria, Belgium, Germany, Finland, France, Luxembourg and Netherlands), while in the second group, we aggregate data for countries with a current account deficit over the sample period (Spain, Greece, Ireland, Italy and Portugal) and which experienced high financial distress.

[2]As underlined by IMF (2013, key issues, p31), financial integration poses a range of specific challenges for the effectiveness of national macroprudential policies. First, lack of forceful macroprudential action in one country can increase the likelihood of crises, imposing negative externalities on other countries. Second, national policies to contain risks from a rapid build-up of domestic credit can lead to an increase in the provision of cross-border credit. Third, policies to strengthen the resilience of systemic institutions in one country can cause their activities to migrate to other countries. Fourth, where financial institutions have affiliates in multiple jurisdictions, this complicates the assessment of systemic risk and can lead to conflicts between home and host authorities.

tool based on credit growth to affect the general equilibrium of the economy through the lending conditions of commercial banks. We more particularly evaluate how the choice of an institutional setting based on the global or regional financial developments of the Eurozone may affect economic outcomes. We build and estimate a two-country DSGE model that includes two key features characterizing the European banking system: cross-border bank lending and diverging financial cycles between core and peripheral countries. Our model accounts for several sources of rigidities to enhance the empirical relevance of the model. The set of real rigidities encompasses consumption habits, investment adjustment costs, loan demand habits. Regarding nominal rigidities, we account for stickiness in final goods prices, wages and loan interest rates. The model is estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q3.

A first set of results focuses on the welfare consequences of alternative ways of implementing macroprudential measures. We get three main results. First, macroprudential policy and monetary policy should be kept separated in the EMU. On one side, we find that an extended interest rate rule has no noticeable effect on welfare with respect to the conduct of an optimal policy that reacts to output and inflation developments. On the other side the separation of authorities allows an heterogeneous treatment of macroprudential policy between countries. Second, our analysis underlines that in all cases a regional setting of parameters dominates the uniform setting of macroprudential parameters. In this situation, macroprudential policy is more reactive in peripheral countries than in core countries. Third, regarding the dimension of the variable to account for in the reaction to financial imbalances, results are not so clear. The reaction to global developments with parameters set at the regional level is Pareto optimal in the monetary union. However, this situation implies a decrease in core county welfare with respect to an optimal monetary policy without macroprudential concerns. In contrast, a granular solution reacting to regional loan creation developments (*i.e.*, taking into account the financial sector rather than borrowers) with parameters set at the regional parameters leads to lower welfare gains at the federal level but implies regional welfare gains in the two parts of the monetary union.

A second set of results is devoted to a counterfactual analysis combining Eurozone financial developments with the conduct of macroprudential policy. We outline the fact that preventive macroprudential measures leaning against the wind provide macro-financial stability in the peripheral countries, as it decreases the variance of investment. Finally, looking at the curative features of macroprudential measures, we find that macroprudential policy is able to strengthen economic recovery in peripheral countries. Again we find that macroprudential measures have no significative impact on core countries' activity. The main curative impact of this policy is observed on the peripheral investment which recovers 6 periods after the crisis.

The chapter is organized as follows: Section 2 presents the related literature. Section 3 describes the financial and macroprudential components of the model. Section 4 presents the standard elements of the model. Section 5 takes the model to the data. Section 6 provides a welfare ranking of the macroprudential policies. Section 7 provides a counterfactual analysis. Section 8 concludes.

2 Relation to the literature

To our knowledge the design of macroprudential measures in the Eurozone has initially been addressed in estimated DSGE models by Darracq-Pariès et al. (2011) and Quint & Rabanal (2013). Darracq-Pariès et al. (2011) develop a one-country DSGE model with both corporate and housing credit markets. They evaluate the performances of different macroprudential tools through an *ad hoc* loss function. They find that capital requirements with countercyclical capital buffers and augmented Taylor rules can play a major role in mitigating the financial distress of the Eurosystem. The authors also explore the perspective of Basel II capital requirements that vary according to the level of risks in the economy (*i.e.* the leverage of households and firms), these risk-sensitive weights on banks assets increase the volatility of the monetary union real GDP by 5 percents and inflation by 4 percents, which induces a welfare loss for households. Finally, they experiment the transitional dynamics of the Euro Area towards higher capital requirements for various implementation dates in a perfect foresight equilibrium. They find that the stabilizing effects of higher capital requirements decrease with the time horizons of implementation.

On the other hand, Quint & Rabanal (2013) develop a two-country model with an housing credit market and compute the welfare gains from implementing macroprudential policies based on the growth of credit supply in the monetary union. They find that implementing macroprudential policy leads to significant gains for households in terms of unconditional consumption. They also find that there are no negative spillover effects of regulation from one member state to another via a two-country DSGE model of the Eurozone. Having macroprudential policies set at the national or EMU wide levels will therefore not change the outcome. Their model focuses on the interaction between financial and housing cycles. As a consequence, it includes a financial accelerator mechanism on the household side, such that changes in the balance sheet of borrowers due to house price fluctuations affect the spread between lending and deposit rates. In their paper, they find that there is no gain of coordinating macroprudential policy. However, this result is obtained in a setting that ignores cross-border bank loans, which is a key component of financial integration in the EMU and may constitute a critical feature to assess the systemic risk at the national level[3] and, by so, to take the right macroprudential decision. This model is very interesting as it allows to study the international dimension of macroprudential policy in an heterogenous monetary union, but the authors focus on the mortgage market where cross-border spillovers between countries are very low[4]. As underlined by the ESRB Flagship Report (2014), a key feature of national macroprudential policies is the international leakage as banks activities transcend national borders.

In our setting, we develop a similar model as Quint & Rabanal (2013) in a two-country set-up with international banking flows on the corporate market using a micro-founded financial accelerator mechanism. We suppose that cross-border decisions arise from the demand side of the credit market. International financial linkages are analogous to the external trade channels, assuming that a CES function aggregates domestic and international lending. This choice - that borrows from the New Open Economy Macroeconomics (NOEM) - remains quite simplistic but offers an interesting feature when going to the empirical estimation of the model and a simple reinterpretation of the financial accelerator from a banking perspective. Under this setting, we are able to fully address the international dimension of macroprudential policy and its cross-border spillovers in an heterogenous monetary union.

3 Cross-Border Bank Loans and the Macroprudential Setting

Our model describes a monetary union made of two asymmetric regions $i \in \{c, p\}$ (where c is for core and p for periphery) inspired by Kolasa (2009). Each area i of the monetary union is of a relative size n_i normalized to 1 such with respective size n and $1-n$ for the core and peripheral area. As shown in Figure 3.2, each country is populated by consumers, intermediate and final producers, entrepreneurs, capital suppliers and a banking system. Regarding the conduct of macroeconomic policy, we assume national fiscal authorities and a common central bank. The implementation of the macroprudential policy is left open, and discussed below. Finally, we close the model in a different fashion than in the previous chapter, we assume that households supply

[3] In countries with a high share of foreign banks and in the absence of information on parent institutions and their exposures, it is difficult to assess domestic systemic risk. Foreign branches, in particular, can become “shadow banks” for the host supervisor and thus increase the systemic risk at the national level.

[4] According to ECB internal data, intra-zone cross-border housing loans only represents 1% of the total of loans for the house purchase in the banks balance sheet of the Euro Area.

deposit to bank rather than buying bonds[5]. We account for several sources of rigidities to enhance the empirical relevance of the model[6].

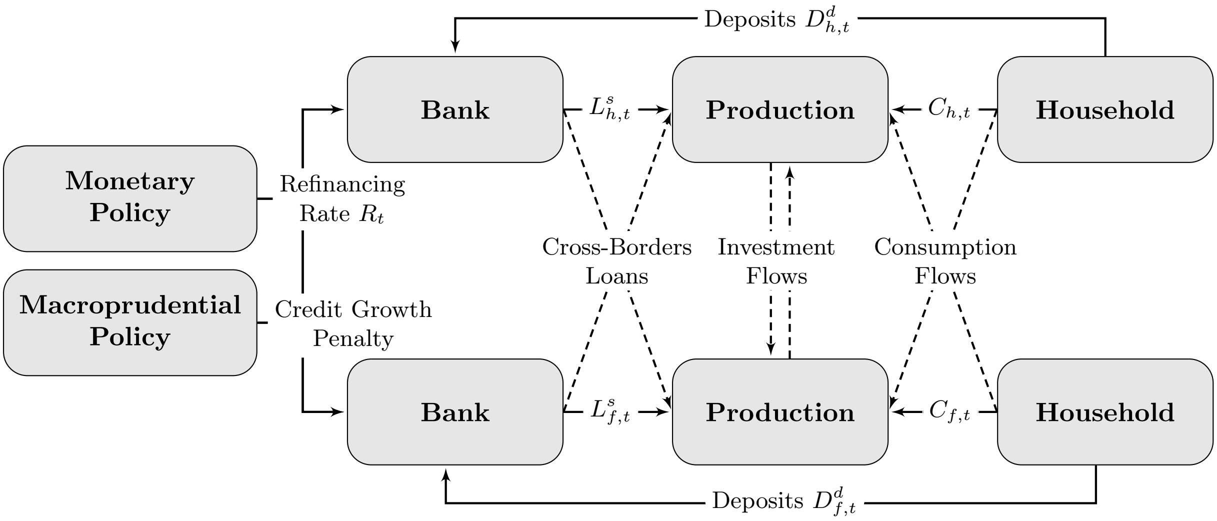


FIGURE 3.2: The model of monetary union with cross-border lending facilities.

This section goes into details on the determination of national interest rates, cross-border banking and on the description of the macroprudential scheme. The rest of the model and general equilibrium conditions are standard and presented in Section 4.

3.1 Entrepreneurs and the Demand for Loans

Cross-border corporate loans occur between entrepreneurs and banks. In each economy, the representative entrepreneur $e \in [0,1]$ finances the capital renting of intermediate firms. In period t, entrepreneur e conducts a great number of heterogenous projects with total value $Q_{i,t}K_{i,t+1}(e)$, where $Q_{i,t}$ is the price of capital and $K_{i,t+1}(e)$ is the amount of capital financed. These projects are financed by his net wealth and by loans from the banking system $(L^d_{i,t+1}(e))$. The balance sheet of the representative entrepreneur writes:

$$Q_{i,t}K_{i,t+1}(e) - N_{i,t+1}(e) = L^{\mathcal{H}}_{i,t+1}(e)\,. \tag{3.1}$$

where $L^{\mathcal{H}}_{i,t+1}(e) = L^d_{i,t+1}(e) - h^L_i\left(L^d_{i,t} - L^d_i\right)$ denotes external demand habits for loans[7]. The entrepreneur has access to domestic and foreign banks to meet its balance sheet.

[5] We are more interested by the banks balance sheet constraint arising from the households deposit supply rather than the current account generated by the households bond purchase.

[6] The set of real rigidities encompasses consumption habits, investment adjustment costs, loan demand habits. Regarding nominal rigidities, we account for stickiness in final goods prices and loan/deposit interest rates.

[7] These lending demand habits are deemed necessary to replicate the dynamic of loans. In the estimation exercise, we use the total stock of loans, they are of different maturities implying a strong autocorrelation. Simply by introducing loan demand habits, taking into account the high autocorrelation of loans becomes tractable easily and does not change the steady state of the model.

The total amount borrowed by the representative entrepreneur writes:

$$L^d_{i,t+1}\left(e\right) = \left(\left(1-\alpha^L_i\right)^{1/\nu} L^d_{h,i,t+1}\left(e\right)^{(\nu-1)/\nu} + \left(\alpha^L_i\right)^{1/\nu} L^d_{f,i,t+1}\left(e\right)^{(\nu-1)/\nu}\right)^{\nu/(\nu-1)}, \quad (3.2)$$

where parameter ν is the elasticity of substitution between domestic and foreign loans, α^L_i represents the percentage of cross-border loan flows in the monetary union and $L^d_{h,i,t+1}\left(e\right)$ (resp. $L^d_{f,i,t+1}\left(e\right)$) the amount of domestic (resp. foreign) loans demanded by entrepreneur e in country i. The total cost of loans, $p^L_{i,t}$, is thus defined according to:

$$p^L_{i,t}\left(e\right) = \left(\left(1-\alpha^L_i\right) r^L_{h,t}\left(e\right)^{1-\nu} + \alpha^L_i r^L_{f,t}\left(e\right)^{1-\nu}\right)^{1/(1-\nu)}, \quad (3.3)$$

where $r^L_{h,t}\left(e\right)$ (resp. $r^L_{f,t}\left(e\right)$) is the cost of loans obtained from home (resp. foreign) banks by entrepreneur e in country i. The decision to borrow from a particular bank is undertaken on the basis of relative national interest rates:

$$L^d_{h,i,t+1}\left(e\right) = \left(1-\alpha^L_i\right)\left[\frac{r^L_{h,t}\left(e\right)}{p^L_{i,t}\left(e\right)}\right]^{-\nu} L^d_{i,t+1}\left(e\right), \text{ and, } L^d_{f,i,t+1}\left(e\right) = \alpha^L_i\left[\frac{r^L_{f,t}\left(e\right)}{p^L_{i,t}\left(e\right)}\right]^{-\nu} L^d_{i,t+1}\left(e\right).$$

The investment projects undertaken by the entrepreneur are risky and differ with respect to their individual returns. To model individual riskiness, we assume that each project has an individual return equal to $\omega R^k_{i,t}$, *i.e.* that the aggregate return of investment projects in the economy $R^k_{i,t}$ is multiplied by a random value ω (drawn from a Pareto distribution[8]). Defining the value for a profitable project by $\bar{\omega}_{i,t}(e) = E\left(\omega|\omega \geq \omega^C_{i,t}(e)\right)$ (where $\omega^C_{i,t}\left(e\right)$ is the critical value of ω that distinguishes profitable and non profitable projects), the profit function of entrepreneur e after aggregating all projects writes:

$$\Pi^E_{i,t+1}\left(e\right) = \begin{cases} \bar{\omega}_{i,t+1}\left(1+r^k_{i,t+1}\right) Q_{i,t} K_{i,t+1}\left(e\right) - \left(1+p^L_{i,t}\left(e\right)\right) L^{\mathcal{H}}_{i,t+1}\left(e\right) \text{ with probability } \eta^E_{i,t+1}, \\ 0 \text{ with probability } 1-\eta^E_{i,t+1}, \end{cases} \quad (3.4)$$

where $\eta^E_{i,t+1}$ is the time-varying expected share of gainful projects. Since entrepreneurs cannot screen the value of $\bar{\omega}_{i,t+1}\left(e\right)$ *ex ante*, $\omega^C_{i,t}(e)$ cannot be a control variable of the financial contract between borrowers and lenders contrary to Bernanke et al. (1999). To introduce a financial accelerator mechanism, we borrow a concept of De Grauwe (2010) applied in a different context, by assuming that entrepreneurs' forecasts regarding the

[8]With respect to the standard framework standardly used in the literature (Bernanke et al., 1999), we assume that the heterogeneity in the return of investment project undertaken by firms is modeled using a Pareto distribution. This device commonly used in other branches of the economic literature provides a series of interesting features in the analysis and allows an easier estimation of the financial amplification effect. See in appendices subsubsection 1.5.2 (page 185) for details about the computation of ω.

aggregate profitability of a given project $\bar{\omega}_{i,t}(e)$ are optimistic (*i.e.*, biased upwards)[9]. The perceived *ex ante* value of profitable projects is defined by the isoleastic function:

$$g\left(\bar{\omega}_{i,t+1},\varepsilon_{i,t}^{Q}\right)=\gamma_i\left(\bar{\omega}_{i,t+1}\right)^{\frac{\varkappa_i}{(\varkappa_i-1)}}\left(e^{\varepsilon_{i,t}^{Q}}\right)^{\frac{1}{(\varkappa_i-1)}},$$

where $\varepsilon_{i,t}^{Q}$ is an $AR(1)$ process[10], $\varkappa_i$ is the elasticity of the external finance premium[11] and γ_i is a scale parameter[12]. In this expression, the exogenous shock is affected by exponent $1/(\varkappa_i-1)$ to normalize to unity the impact of the financial shock $\varepsilon_{i,t}^{Q}$ in the log deviation form of the model. Thus, *ex-ante* the entrepreneur chooses a capital value of $K_{i,t+1}(e)$ that maximizes its expected profit defined as:

$$\max_{\{K_{i,t+1}(e)\}}\mathbb{E}_t\left\{\eta_{i,t+1}^{E}\left[g\left(\bar{\omega}_{i,t+1},\varepsilon_{i,t}^{Q}\right)\left(1+r_{i,t+1}^{k}\right)Q_{i,t}K_{i,t+1}(e)-\left(1+p_{i,t}^{L}(e)\right)L_{i,t+1}^{\mathcal{H}}(e)\right]\right\}. \tag{3.5}$$

Using the characteristics of the Pareto distribution, the expected spread required by representative entrepreneur e to undertake the decision to finance firms' investment is:

$$S_{i,t}(e)=\frac{\mathbb{E}_t\left(1+r_{i,t+1}^{k}\right)}{1+p_{i,t}^{L}(e)}=\gamma_i^{\varkappa_i-1}\left[\frac{\kappa}{\kappa-1}\left(1-\frac{N_{i,t+1}(e)}{Q_{i,t}K_{i,t+1}(e)}\right)\right]^{\varkappa_i}e^{\varepsilon_{i,t}^{Q}}. \tag{3.6}$$

The size of the accelerator is determined by the elasticity of the external finance premium $\varkappa_i$. For $\varkappa_i>0$, the external finance premium is a positive function of the leverage ratio, $Q_{i,t}K_{i,t+1}(e)/N_{i,t+1}(e)$, so that an increase in net wealth induces a reduction of the external finance premium. This phenomenon disappears if $\varkappa_i=0$. Concerning the exogenous movements of the external finance premium, a positive realization of $\varepsilon_{i,t}^{Q}$ means that entrepreneurs require a higher expected profitability of capital $E_t r_{i,t+1}^{k}$ to finance investment for a given level of lending conditions $p_{i,t}^{L}$. Furthermore, a shock that hits the entrepreneur net wealth $N_{i,t+1}(e)$ will also affect the rentability of the physical capital in the economy. As the rentability of capital is a cost for the intermediate sector, a variation in the net wealth will have aggregate consequences on goods supply through the channel of the capital market as underlined by Gilchrist, Sim, & Zakrajsek (2009). The amount of capital of non-profitable entrepreneurs' investment projects is consumed

[9]Assuming optimistic firms is motivated empirally, Bachmann & Elstner (2013) find evidence of such expectations for German firms using microdata. This hypothesis of the expectations of the private sector is very close to the utility functions introduced by Goodhart et al. (2005) for bankers. In our setting, the financial accelerator does not result from a moral hazard problem but rather from a bias in the expectations of the private sector.

[10]This shock affects the expected profitability of financial projects by rising in exogeneously the risk premium implying an increase in the cost of capital and hence a reduction in investment as underlined by Gilchrist, Sim, & Zakrajsek (2009) for the US economy.

[11]The elasticity of the external finance premium expresses the degree of bias in estimating the expected rentability of entrepreneurs' projects such that if $\bar{\omega}>1$ and $\varkappa_i>0$ then $g(\bar{\omega})>\bar{\omega}$. Expressed *à la* De Grauwe (2010), $\mathbb{E}_t^{opt}\bar{\omega}_{i,t+1}=\mathbb{E}_t\gamma_i\left(\bar{\omega}_{i,t+1}\right)^{\varkappa_i/(\varkappa_i-1)}$ where $\mathbb{E}_t^{opt}$ is the expectation operator of optimistic entrepreneurs.

[12]This parameter is needed to make the steady state independent of $\varkappa_i$,such that $\gamma_i=\bar{\omega}^{1/(1-\varkappa_i)}$.

in terms of home final goods $P_{i,t}\left(1-\eta^E_{i,t}\right)\underline{\omega}_{i,t}(e)\left(1+r^k_{i,t}\right)Q_{i,t-1}K_{i,t}(e)$. Thus the net wealth of the entrepreneur in the next period is equal to:

$$N_{i,t+1}(e)=\left(1-\tau^E_i\right)\frac{\Pi^E_{i,t}(e)}{e^{\varepsilon^N_{i,t}}}, \tag{3.7}$$

where $\varepsilon^N_{i,t}$ is an exogenous process of net wealth destruction and τ^E_i is a proportional tax on the profits of the bank.

3.2 The Banking Sector and the Imperfect Pass-Through of Policy Rate

The representative bank b in country i collects deposits from households and lends to firms. The balance sheet of the bank writes:

$$L^s_{i,t+1}(b)=D_{i,t+1}(b)+L^{RF}_{i,t+1}(b)+BK_{i,t+1}(b). \tag{3.8}$$

In this expression, $L^s_{i,t}$ is the total level of loans supplied by bank b, $D_{i,t}(b)$ is the total level of deposit services offered by bank b of country i to households, $L^{RF}_{i,t+1}(b)$ is the one-period refinancing loans to banks by the ECB and $BK_{i,t+1}(b)$ is the bank capital. The representative bank sets the rate of interest $r^L_{i,t}(b)$ and $r^D_{i,t}(b)$.

Banks finance heterogenous investment projects conducted by home and foreign entrepreneurs, some of these projects are gainful with a probability $\eta_{i,t+1}$. Following Bernanke et al. (1999), if the borrower's project is gainful, the representative bank obtains $\eta_{i,t+1}(1+r^L_{i,t}(b))L^s_{i,t+1}(b)$, whereas if the entrepreneur's project is insolvent, the bank must pay auditing costs μ^B to obtain its loan[13], thereby the expected value of next period earnings is:

$$\begin{aligned}\mathbb{E}_t\Pi^B_{i,t+1}(b)=&\underbrace{\left[\mathbb{E}_t\eta_{i,t+1}+\left(1-\mu^B\right)\left(1-\eta_{i,t+1}\right)\right]\left(1+r^L_{i,t}(b)\right)L^s_{i,t+1}(b)}_{\text{Revenues from loan supply activities}}\\&-\underbrace{\left(1+r_t\right)L^{RF}_{i,t+1}(b)}_{\text{ECB refinancing cost}}-\underbrace{\left(1+r^D_{i,t}\right)D_{i,t+1}(b)}_{\text{Deposit cost}}.\end{aligned} \tag{3.9}$$

In this setting, we assume that there is no discrimination between borrowers, so that the representative and risk-neutral bank serves both domestic and foreign entrepreneur without taking into account specificities regarding the national viability of projects. Since banks lend to both home and foreign entrepreneurs, the expected share of profitable

[13] *i.e.*, banks recover $\left(1-\mu^B\right)\left(1-\eta_{i,t+1}\right)\left(1+R^L_{i,t}(b)\right)L^s_{i,t+1}(b)$: we borrow this shortcut from Benes et al. (2014) which is a tractable and easier way to introdue the loss given to default μ^B than in the inial framework of Bernanke et al. (1999) where investors have a technology to size the collateral in case of default.

projects is determined by a geometric average, $\eta_{i,t} = \left(\eta^E_{h,t}\right)^{\left(1-\alpha^L_h\right)} \left(\eta^E_{f,t}\right)^{\alpha^L_f} \bar{\eta}^{\left(\alpha^L_h-\alpha^L_f\right)}$ where $\overline{\eta}$ is the steady state share of profitable investment projects[14]. Concerning bank capital, we follow Hirakata et al. (2009) by assuming the law of motion of the net wealth is made of the profits of the previous period:

$$BK_{i,t+1}(b) = \left(1 - \tau^B_i\right) \Pi^B_{i,t}(b), \tag{3.10}$$

where τ^B_i denotes a proportional tax on the revenues of the bank by national governments[15].

As in Darracq-Pariès et al. (2011), we take into account the imperfect pass-through of policy rate on bank lending/deposit rates. We suppose that banks set their interest rates on a staggered basis with some degree of nominal rigidity *à la* Calvo.

3.2.1 Loan supply decisions

The determination of interest rate on loans is as follows: the representative bank b maximizes expected profit from Equation 3.9 with respect to $L^s_{i,t+1}(b)$ to obtain the expression of the marginal cost of producing new loans:

$$1 + MC^L_{i,t}(b) = \frac{(1 + r_t)}{\left[1 - \mu^B\left(1 - \mathbb{E}_t\eta_{i,t+1}\right)\right]}. \tag{3.11}$$

The representative retail bank b acts monopolistically to provide loans to entrepreneurs. It determines the interest rate on loans contracted by entrepreneurs. Assuming that it is able to modify its loan interest rate with a probability $1 - \theta^L_i$, it chooses $r^{L*}_{i,t}(b)$ to maximize its expected sum of profits:

$$\max_{\left\{R^{L*}_{i,t}(b)\right\}} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} \left(\theta^L_i\beta\right)^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[r^{L*}_{i,t}(b) - MC^L_{i,t+\tau}\right] L_{i,t+1+\tau}(b) \right\},$$

subject to the demand constraint, $L_{i,t+1+\tau}(b) = \frac{1}{n_i}\left(r^{L*}_{i,t}(b)/r^L_{i,t+\tau}\right)^{-\epsilon_L} L_{i,t+1+\tau}$, $\tau > 0$, where $L_{i,t}(b)$ denotes the quantity of differentiated banking loans b that is used in loans packer production. Finally, the interest rate that solves the FOC for the bank that is allowed to modify its interest rate, it is such that:

$$\mathbb{E}_t \sum_{\tau=0}^{\infty} \left(\theta^L_i\beta\right)^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[r^{L*}_{i,t}(b) - \frac{\epsilon_L}{(\epsilon_L - 1)} MC^L_{i,t+\tau}\right] L_{i,t+1+\tau}(b) = 0. \tag{3.12}$$

[14] In steady state, we suppose that banks are symmetric between countries such that when $\overline{\eta} = \overline{\eta}^E_h = \overline{\eta}^E_f$ and $\varepsilon^b = \varepsilon^b_h = \varepsilon^b_f$, then $R^L = R^L_h = R^L_f$.

[15] This tax is necessary to solve up the model in steady state. Bernanke et al. (1999) and Hirakata et al. (2011) also add a proportional cost in law of motion of the net wealth.

3.2.2 Deposit supply decisions

We proceed accordingly for the determination of deposit interest rate. The nominal marginal cost of one unit of deposit denoted by $MC_{i,t}^{D}$ is the same across banks and is related to the ECB refinancing rate:

$$1 + MC_{i,t}^{D}(b) = 1 + MC_{i,t}^{D} = (1 + r_t). \tag{3.13}$$

Assuming sticky deposit rates, the expected sum of profits for the bank that is allowed to modify its interest rate with a probability $1 - \theta_i^D$ writes:

$$\max_{\left\{R_{i,t}^{D*}(b)\right\}} E_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^D \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}} \left[MC_{i,t+\tau}^{D} - r_{i,t}^{D*}(b)\right] D_{i,t+1+\tau}(b) \right\}, \tag{3.14}$$

under the constraint, $D_{i,t+1+\tau}(b) = \frac{1}{n_i}\left(r_{i,t}^{D*}(b)/r_{i,t+\tau}^{D}\right)^{-\mu_{i,t+\tau}^{D}/\left(\mu_{i,t+\tau}^{D}-1\right)} D_{i,t+1+\tau}^{d}$, $\forall \tau > 0$, where $\mu_{i,t}^{D} = \epsilon^D / \left(\epsilon^D - 1\right) + \varepsilon_{i,t}^{D}$ is the time-varying markup subject to the exogenous deposit rate-push shock process $\varepsilon_{i,t}^{D}$. The interest rate that solves the FOC for the bank that is allowed to modify its interest rate writes:

$$\sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^D \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}} \frac{1}{\mu_{i,t+\tau}^{D} - 1} \left[r_{i,t}^{D*}(b) - \mu_{i,t+\tau}^{D} MC_{i,t+\tau}^{D}\right] D_{i,t+1+\tau}(b) = 0. \tag{3.15}$$

3.3 Macroprudential Policy

As in Fatas & et al. (2009), Quint & Rabanal (2013) and Bailliu et al. (2012) we introduce a macroprudential tool based on credit growth to affect the general equilibrium of the economy through the lending conditions of commercial banks. We more particularly evaluate how the choice of a particular institutional setting based on the global or regional financial developments of the Eurozone may affect economic outcomes. As shown in Table 3.1, our analysis contrasts seven situations, combining the definition of the global or regional value of the macroprudential instrument and the uniform or heterogenous setting of the macroprudential parameter between member countries.

Global solutions: under this macroprudential scheme, authorities react to the average per capita credit growth in the Monetary Union[16]. We contrast three possibilities: in the first situation, the macroprudential concern of the authorities gives rise to an extended interest rate of the central bank. The monetary policy rule is augmented to allow the

[16] Namely we set $\mathcal{MP}_{u,t} = \left(L_{c,t}^{s}/L_{c,t-1}^{s}\right)^{n}\left(L_{p,t}^{s}/L_{p,t-1}^{s}\right)^{1-n}$.

policy interest rate to react to the average credit growth in Equation 3.22:

$$1 + r_t = f\left(\pi_{u,t}, Y_{u,t}\right) \times \left(\mathcal{MP}_{u,t}\right)^{\phi},$$

where $\mathcal{MP}_{u,t}$ is the macroprudential instrument and ϕ is the macroprudential policy stance on the central bank interest rate. Under this first scheme, lending and deposit conditions are affected by macroprudential policy through the cost of bank refinancing by the central bank open market decisions. This situation will be treated below as a variant of the optimal monetary policy rule set by the central bank.

In the second and third situations macroprudential measures are implemented at the commercial bank level, through the marginal cost of loan production and are totally separated from monetary policy decisions. A tightening of credit conditions due to macroprudential measures increases the interest rate faced by borrowers by modifying the marginal cost of credit (see Equation 3.11) in the economy[17]:

$$1 + MC^L_{i,t} = \frac{\left(1 + r_t\right)\left(\mathcal{MP}_{i,t}\right)^{\phi_i}}{1 - \mu^B\left(1 - \mathbb{E}_t\eta_{i,t+1}\right)}. \tag{3.16}$$

We consider that macroprudential authorities are concerned by credit growth and lean against the build-up of emerging financial imbalances. In the second situation, macroprudential authorities penalize the average growth of credit by affecting proportionally the lending rate of bank in Equation 3.16 with a common degree of penalization $\phi_h = \phi_f$ taking into account average developments in the Eurozone systemic risk. In the third situation, macroprudential authorities penalize the average growth of credit by affecting proportionally the lending rate of bank in Equation 3.16 with a degree of penalization set at the regional level ($\phi_h \neq \phi_f$).

National solutions: under this macroprudential scheme, measures take into account the regional evolution of loans (i.e., $\mathcal{MP}_{h,t} \neq \mathcal{MP}_{f,t}$) but apply a similar uniform parameter to all the participating countries (i.e., $\phi_c = \phi_p = \phi$). However, as cross border lending leads to alternative way of implementing macroprudential measures at the national level (focussing on lenders or borrowers) we take into account two possibilities. In the first situation, macroprudential authorities focus on the evolution of loan supply in their economy (i.e., react to the lending decision of their national banking sector) so that, $\mathcal{MP}_{i,t} = \left(L^s_{i,t}/L^s_{i,t-1}\right)$ for $i \in \{c, p\}$. This solution provides a common reaction of national financial developments in each part of the monetary union. In the second situation, macroprudential authorities focus on the evolution of loan demand in their economy (i.e., react to the borrowing decision of national entrepreneur) so that, $\mathcal{MP}_{i,t} =$

[17]Under staggered interest rates, the diffusion of the macroprudential policy does not work perfectly as there is imperfect pass-through.

Scenario	Instrument	Policy Stance	Policy Channel
Extended rule	$\mathcal{MP}_{u,t} = \left(L^s_{c,t}/L^s_{c,t-1}\right)^n \left(L^s_{p,t}/L^s_{p,t-1}\right)^{1-n}$	$\phi_c = \phi_p = \phi$	$1 + r_t = f\left(\pi_{u,t}, Y_{u,t}\right) \times \left(\mathcal{MP}_{u,t}\right)^{\phi}$
Global 1	$\mathcal{MP}_{u,t} = \left(L^s_{c,t}/L^s_{c,t-1}\right)^n \left(L^s_{p,t}/L^s_{p,t-1}\right)^{1-n}$	$\phi_c = \phi_p = \phi$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{u,t}\right)^{\phi}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$
Global 2	$\mathcal{MP}_{u,t} = \left(L^s_{c,t}/L^s_{c,t-1}\right)^n \left(L^s_{p,t}/L^s_{p,t-1}\right)^{1-n}$	$\phi_c \neq \phi_p$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{u,t}\right)^{\phi_i}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$
National 1	$\mathcal{MP}_{i,t} = \left(L^s_{i,t}/L^s_{i,t-1}\right)$ for $i \in \{c, p\}$	$\phi_c = \phi_p = \phi$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{i,t}\right)^{\phi}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$
National 2	$\mathcal{MP}_{i,t} = \left(L^d_{i,t}/L^d_{i,t-1}\right)$ for $i \in \{c, p\}$	$\phi_c = \phi_p = \phi$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{i,t}\right)^{\phi}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$
Granular 1	$\mathcal{MP}_{i,t} = \left(L^s_{i,t}/L^s_{i,t-1}\right)$ for $i \in \{c, p\}$	$\phi_c \neq \phi_p$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{i,t}\right)^{\phi_i}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$
Granular 2	$\mathcal{MP}_{i,t} = \left(L^d_{i,t}/L^d_{i,t-1}\right)$ for $i \in \{c, p\}$	$\phi_c \neq \phi_p$	$1 + MC^L_{i,t} = \frac{(1+r_t)\left(\mathcal{MP}_{i,t}\right)^{\phi_i}}{\left[1-\mu^B\left(1-\mathbb{E}_t\eta_{i,t+1}\right)\right]}$

TABLE 3.1: Different levels of implementation of Macroprudential policy

$\left(L^d_{i,t}/L^d_{i,t-1}\right)$ for $i \in \{c, p\}$. This solution is interesting as it takes into account foreign loan supply directed towards the domestic economy (and *vice-versa*).

Granular solutions: granular solution combines a national appreciation of the evolution of loans and a national setting of the macroprudential parameter. In the first situation, authorities focus on lenders (*i.e.*, on the banking system) and by so directly affect the main origin of the distribution of loans in the economy (captured by the home bias in loan demand). Here, $\mathcal{MP}_{i,t} = \left(L^s_{i,t}/L^s_{i,t-1}\right)$ for $i \in \{c, p\}$ with $\phi_c \neq \phi_p$. In this situation, authorities are not able to address the exact quantity of loans contracted in the economy (the quantify of loans distributed by foreign banks in the economy is not accounted for in $L^s_{i,t}$ while the quantity of national loans sold to foreign entrepreneurs is part of $L^s_{i,t}$). This in turn, implies a wrong evaluation of the evolution of systemic risk in the economy and generates externalities between member countries of the monetary union (as the national macroprudential stance affects the other economy through the lending conditions to foreign agents). In the second situation authorities focus on borrowers (Here, $\mathcal{MP}_{i,t} = \left(L^d_{i,t}/L^d_{i,t-1}\right)$ for $i \in \{c, p\}$ with $\phi_c \neq \phi_p$.). Authorities have a better understanding of the amount of loans contracted by national agents (*i.e.*, this system eliminates the shadow nature of the foreign banks that operate domestically). However in this situation they are unable to affect directly the origin of loan distribution.

4 The rest of the model

Due to the asymmetry between countries, for each variable denoted $X_{i,t}\left(x\right)$, we aggregate households, firms, entrepreneurs and banks using the following aggregator for agent

$x \in [0, n_p + n_c]$ living in the monetary union:

$$\mathcal{G}\left(X_{i,t}\left(x\right)\right) = \begin{cases} \int_0^n X_{c,t}\left(x\right) \mathrm{d}x \text{ for } i = c \\ \int_n^1 X_{p,t}\left(x\right) \mathrm{d}x \text{ for } i = p \end{cases} . \tag{3.17}$$

4.1 Households

In each economy there is a continuum of identical households who consume, save and work in intermediate firms. The total number of households is normalized to 1. The representative household $j \in [0,1]$ maximizes the welfare index:

$$\max_{\left\{C_{i,t}(j), H_{i,t}(j), D^d_{i,t+1}(j)\right\}} \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} e^{\varepsilon^U_{i,t+\tau}} \left[\frac{\left(C_{i,t+\tau}\left(j\right) - h^C_i C_{i,t-1+\tau}\right)^{1-\sigma^C_i}}{1-\sigma^C_i} - \chi_i \frac{H^{1+\sigma^L_i}_{i,t+\tau}\left(j\right)}{1+\sigma^L_i} \right], \tag{3.18}$$

subject to:

$$\frac{W_{i,t}}{P^C_{i,t}} H_{i,t}\left(j\right) + \left(1 + r^D_{i,t-1}\right) \frac{D^d_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{\Pi^Y_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{\bar{M}_i\left(j\right)}{P^C_{i,t}} = C_{i,t}\left(j\right) + \frac{D^d_{i,t+1}\left(j\right)}{P^C_{i,t}} + \frac{T_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{P_{i,t}}{P^C_{i,t}} AC^D_{i,t}\left(j\right)$$

Here, $C_{i,t}\left(j\right)$ is the consumption index, $h^C_i \in [0,1]$ is a parameter that accounts for external consumption habits, $H_{i,t}\left(j\right)$ is labor effort, $\varepsilon^U_{i,t}$ is an exogenous $AR(1)$ shock to household preferences. The income of the representative household is made of labor income (with nominal wage, $W_{i,t}$), interest payments for deposits, (where $D^d_{i,t}\left(j\right)$ stands for the deposit subscribed in period $t-1$ and $1 + r^D_{i,t-1}$ is the gross nominal rate of interest between period $t-1$ an period t), and earnings $\Pi^Y_{i,t}\left(j\right)$ from shareholdings. The representative household spends this income on consumption, deposits and tax payments (for a nominal amount of $T_{i,t}\left(j\right)$). Finally, he has to pay quadratic adjustment costs to buy new deposit services (Schmitt-Grohé & Uribe, 2003), according to the function, $AC^D_{i,t}\left(j\right) = \frac{\chi^D_i}{2} \frac{\left(D^d_{i,t+1}(j) - \bar{D}^d_i(j)\right)^2}{\bar{D}^d_i(j)}$, where $\bar{D}^d_i\left(j\right)$ is the steady state level of deposits. In order to make the households/banks deposit problem tractable in the steady state[18], we assume that households hold a constant quantity of real money balances $\bar{M}_i\left(j\right)$.

The first order conditions that solve this problem can be summarized with an Euler condition:

$$\frac{\beta\left(1 + r^D_{i,t}\right)}{1 + P_{i,t} AC^{D\prime}_{i,t}\left(j\right)} = \mathbb{E}_t \left\{ \frac{e^{\varepsilon^U_{i,t}}}{e^{\varepsilon^U_{i,t+1}}} \frac{P^C_{i,t+1}}{P^C_{i,t}} \left(\frac{C_{i,t+1}\left(j\right) - h^C_i C_{i,t}}{C_{i,t}\left(j\right) - h^C_i C_{i,t-1}} \right)^{\sigma^C_i} \right\}, \tag{3.19}$$

[18] The lending supply is asymmetric between the two areas wich implies asymmetric refinancing operations and deposits. In order to have symmetric households in steady state between core and periphery, we suppose that households hold a constant quantity of real money balances.

and a labor supply function:

$$\frac{W_{i,t}}{P^C_{i,t}} = \chi_i H_{i,t}\left(j\right)^{\sigma^L_i}\left(C_{i,t}\left(j\right) - h^C_i C_{i,t-1}\right)^{\sigma^C_i}. \tag{3.20}$$

The consumption basket of the representative household and the consumption price index of country i are, $C_{i,t}(j) = (\left(1-\alpha^C_i\right)^{1/\mu} C_{h,i,t}(j)^{(\mu-1)/\mu} + \left(\alpha^C_i\right)^{1/\mu} C_{f,i,t}\left(j\right)^{(\mu-1)/\mu})^{\mu/(\mu-1)}$ and $P^C_{i,t} = (\left(1-\alpha^C_i\right) P^{1-\mu}_{h,t} + \alpha^C_i P^{1-\mu}_{f,t})^{1/(1-\mu)}$ where μ is the elasticity of substitution between the consumption of home $(C_{h,i,t}(j))$ and foreign $(C_{f,i,t}\left(j\right))$ goods and α^C_i is the degree of openness of the economy i. In this model, we assume home bias in consumption, so that $\alpha^C_i < \frac{1}{2}$.

4.2 Firms

This sector is populated by two groups of agents: intermediate firms and final firms. Intermediate firms produce differentiated goods i, choose labor and capital inputs, and set prices according to the Calvo model. Final goods producers act as a consumption bundler by combining national intermediate goods to produce the homogenous final good[19].

Concerning the representative intermediate firm i, it has the following technology, $Y_{i,t}\left(i\right) = e^{\varepsilon^A_{i,t}} K_{i,t}\left(i\right)^{\alpha} H^d_{i,t}\left(i\right)^{1-\alpha}$, where $Y_{i,t}\left(i\right)$ is the production function of the intermediate good that combines capital $K_{i,t}\left(i\right)$, labor $H^d_{i,t}\left(i\right)$ and technology $e^{\varepsilon^A_{i,t}}$ (an $AR(1)$ productivity shock). Intermediate goods producers solve a two-stages problem. In the first stage, given the input prices $W_{i,t}$ and $Z_{i,t}$ as given, firms rent inputs $H^d_{i,t}\left(i\right)$ and $K_{i,t}\left(i\right)$ in a perfectly competitive factor markets in order to minimize costs subject to the production constraint. The first order condition leads to the marginal cost expression:

$$MC_{i,t}(i) = MC_{i,t} = \frac{1}{e^{\varepsilon^A_{i,t}}}\left(\frac{Z_{i,t}}{\alpha}\right)^{\alpha}\left(\frac{W_{i,t}}{(1-\alpha)}\right)^{(1-\alpha)}. \tag{3.21}$$

From the cost minimization problem, inputs also satisfy, $\alpha H^d_{i,t}\left(i\right) W_{i,t} = Z_{i,t} K_{i,t}\left(i\right)\left(1-\alpha\right)$.

In the second-stage, firm i sets the price according to a Calvo mechanism. Each period firm i is not allowed to reoptimize its price with probability θ^P_i but price increases of $\xi^P_i \in [0;1]$ at last period's rate of price inflation, $P_{i,t}\left(i\right) = \pi^{\xi^P_i}_{i,t-1} P_{i,t-1}\left(i\right)$. The firm allowed to modify its selling price with a probability $1-\theta^P_i$ chooses $\left\{P^*_{i,t}(i)\right\}$ to maximize

[19] Final good producers are perfectly competitive and maximize profits, $P_{i,t} Y^d_{i,t} - \mathcal{G}\left(P_{i,t}\left(i\right) Y_{i,t}\left(i\right)\right)$, subject to the production function $Y^d_{i,t} = ((1/n_i)^{1/\epsilon_P}\, \mathcal{G}\left(Y_{i,t}\left(i\right)^{(\epsilon_P-1)/\epsilon_P}\right))^{\epsilon_P/(\epsilon_P-1)}$. We find the intermediate demand functions associated with this problem are, $Y_{i,t}\left(i\right) = \left(1/n_i\right)\left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_P} Y^d_{i,t}$, $\forall i$. where $Y^d_{i,t}$ is the aggregate demand.

its expected sum of profits:

$$\max_{\left\{P^*_{i,t}(i)\right\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^P \beta\right)^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[\frac{P^*_{i,t}(i)}{P^C_{i,t+\tau}} \prod_{k=1}^{\tau} \pi^{\xi_i^P}_{i,t+k-1} - \frac{MC_{i,t+\tau}}{P^C_{i,t+\tau}} \right] Y_{i,t+\tau}(i) \right\},$$

under the demand constraint:

$$Y_{i,t+\tau}(i) = \frac{1}{n_i} \left(\prod\nolimits_{k=1}^{\tau} \pi^{\xi_i^P}_{i,t+k-1} \frac{P^*_{i,t}(i)}{P_{i,t+\tau}} \right)^{-\epsilon_P} Y^d_{i,t+\tau}, \quad \forall\, \tau > 0,$$

where $Y^d_{i,t}$ represents the quantity of the goods produced in country i and $\lambda^c_{i,t}$ the household marginal utility of consumption.

4.3 Monetary Policy

The central bank of the monetary union follows an interest rate rule defined by:

$$\left(\frac{1+r_t}{1+\bar{r}}\right) = \left(\frac{1+r_{t-1}}{1+\bar{r}}\right)^\rho \left(\left(\pi^C_{u,t}\right)^{\phi^\pi} \left(\frac{Y_{u,t}}{Y_{u,t-1}}\right)^{\phi^{\Delta y}} \right)^{(1-\rho)} e^{\varepsilon^R_t}, \tag{3.22}$$

where r_t is the interest rate set by the central bank, ρ is the interest rate smoothing coefficient, ε^R_t is an exogenous AR(1) monetary policy shock common to the monetary union members, ϕ^π is the level of reaction to inflation, $\phi^{\Delta y}$ is the GDP growth target. In this expression, union-wide inflation and GDP growth are defined by a geometric average that account for the relative size of each country, $\pi^C_{u,t} = \left(\pi^C_{c,t}\right)^n \left(\pi^C_{p,t}\right)^{1-n}$ and $Y_{u,t} = \left(Y_{c,t}\right)^n \left(Y_{p,t}\right)^{1-n}$.

4.4 Capital Suppliers

Capital suppliers are homogeneous and distributed over a continuum normalized to one. The representative capital supplier k acts competitively to supply a quantity $K_{i,t+1}(k)$ of capital. Investment is costly, *i.e.* the capital supplier pays an adjustment cost $AC^I_{i,t}(k)$ on investment, such that $AC^I_{i,t}(k) = \frac{\chi^I_i}{2}\left(e^{\varepsilon^I_{i,t}} I_{i,t}(k)/I_{i,t-1}(k) - 1\right)^2$ where $\varepsilon^I_{i,t}$ is an exogenous adjustment cost shock on investment. The capital stock of the representative capital supplier thus evolves according to:

$$K_{i,t+1}(k) = \left(1 - AC^I_{i,t}(k)\right) I_{i,t}(k) + (1-\delta) K_{i,t}(k).$$

The capital supplier produces the new capital stock $Q_{i,t} K_{i,t+1}(k)$ by buying the depreciated capital $Q_{i,t}(1-\delta) K_{i,t}(k)$ and investment goods $P^I_{i,t} I_{i,t}(k)$ where:

$$I_{i,t}(k) = \left(\left(1-\alpha^I_i\right)^{1/\mu} I_{hi,t}(k)^{(\mu-1)/\mu} + \left(\alpha^I_i\right)^{1/\mu} I_{fi,t}(k)^{(\mu-1)/\mu} \right)^{\mu/(\mu-1)},$$

and:

$$P^I_{i,t} = \left(\left(1-\alpha^I_i\right)\left(P_{h,t}\right)^{1-\mu} + \alpha^I_i\left(P_{f,t}\right)^{1-\mu}\right)^{1/(1-\mu)}.$$

In this expression, parameter μ is the elasticity of substitution between domestic and foreign goods in investment and $\alpha^I_i < 0.5$ measures the degree of investment diversification in the monetary union between home and foreign countries. The representative capital supplier chooses $I_{i,t}(k)$ to maximize profits:

$$\max_{\{I_{i,t}(k)\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \beta^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[Q_{i,t}\left(1 - AC^I_{i,t}(k)\right) - P^I_{i,t}\right] I_{i,t}(k) \right\},$$

where $\beta^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}}$ is the household stochastic discount factor. The price of capital renting thus solves:

$$Q_{i,t} = P^I_{i,t} + Q_{i,t}\frac{\partial\left(I_{i,t}(k)\, AC^I_{i,t}(k)\right)}{\partial I_{i,t}(k)} + \beta\mathbb{E}_t\frac{\lambda^c_{i,t+1}}{\lambda^c_{i,t}}Q_{i,t+1}\frac{\partial\left(I_{i,t+1}(k)\, AC^I_{i,t+1}(k)\right)}{\partial I_{i,t}(k)}.$$

Thus, the real return from holding one unit of capital from t to $t+1$ is determined by:

$$\mathbb{E}_t\frac{\left(1+r^k_{i,t+1}\right)}{\pi^C_{i,t+1}} = \mathbb{E}_t\left[\frac{Z_{i,t+1}/P^C_{i,t+1} + (1-\delta)\, Q_{i,t+1}/P^C_{i,t+1}}{Q_{i,t}/P^C_{i,t}}\right]. \tag{3.23}$$

4.5 Governments

National governments finance public spending by charging proportional taxes on the bank capital τ^B_i, net wealth of entrepreneurs τ^E_i and by receiving a total value of taxes $\mathcal{G}(T_{i,t}(j))$ from households. The budget constraint of the national government writes:

$$\mathcal{G}(T_{i,t}(j)) + \tau^E_i\mathcal{G}(N_{i,t}(e)) + \tau^B_i\mathcal{G}(BK_{i,t}(b)) = P_{i,t}G_{i,t} = P_{i,t}\bar{G}\varepsilon^G_{i,t},$$

where $G_{i,t}$ is the total amount of public spending in the i^{th} economy that follows an AR(1) shock process. Following Smets & Wouters (2007), we assume that exogenous spending is affected by the productivity shock at a degree ρ^{ag}_i such that $\varepsilon^G_{i,t} = \rho^G_i\varepsilon^G_{i,t-1} + \eta^G_{i,t} + \rho^{ag}_i\eta^A_{i,t}$. The government demand for home goods writes, $G_{i,t}(i) = \left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_P} G_{i,t}$.

4.6 Aggregation and Market Equilibrium

In this model, there are 8 country specific structural shocks for $i \in \{c,p\}$ and one common shock in the Taylor rule. For $s = \{U, A, I, Q, N, D\}$, the shocks follow a first order autoregressive process such that $\varepsilon^s_{i,t} = \rho^s_i \varepsilon^s_{i,t-1} + \eta^s_{i,t}$ while for exogenous spending the process reads as follows: $\varepsilon^G_{i,t} = \rho^G_i \varepsilon^G_{i,t-1} + \eta^G_{i,t} + \rho^{ag}\eta^A_{i,t}$. In these first-order autoregressive process, ρ^U_i, ρ^A_i, ρ^G_i, ρ^I_i, ρ^Q_i, ρ^N_i, ρ^D_i and ρ^R are autoregressive roots of the exogenous variables. $\eta^U_{i,t}$, $\eta^A_{i,t}$, $\eta^G_{i,t}$, $\eta^I_{i,t}$, $\eta^Q_{i,t}$, $\eta^N_{i,t}$, $\eta^D_{i,t}$ and η^R_t are standard errors that are mutually independent, serially uncorrelated and normally distributed with zero mean and variances $\sigma^2_{i,U}$, $\sigma^2_{i,A}$, $\sigma^2_{i,G}$, $\sigma^2_{i,I}$, $\sigma^2_{i,Q}$, $\sigma^2_{i,N}$, $\sigma^2_{i,D}$ and σ^2_R respectively. A general equilibrium is defined as a sequence of quantities $\{\mathcal{Q}_t\}^\infty_{t=0}$ and prices $\{\mathcal{P}_t\}^\infty_{t=0}$ such that for a given sequence of quantities $\{\mathcal{Q}_t\}^\infty_{t=0}$ and the realization of shocks $\{\mathcal{S}_t\}^\infty_{t=0}$, the sequence $\{\mathcal{P}_t\}^\infty_{t=0}$ guarantees the equilibrium on the capital, labor, loan, intermediate goods and final goods markets.

After (i) aggregating all agents and varieties in the economy, (ii) imposing market clearing for all markets, (iii) substituting the relevant demand functions, we deduct the general equilibrium conditions of goods, loans and deposit services markets.

4.6.1 Goods Market

The aggregate price index of the national goods evolves according to:

$$P^{1-\epsilon_P}_{i,t} = \theta^P_i \left[P_{i,t-1} \left(\frac{P_{i,t-1}}{P_{i,t-2}} \right)^{\xi^P_i} \right]^{1-\epsilon_P} + \left(1-\theta^P_i\right) \left(P^*_{i,t}\right)^{1-\epsilon_P}. \tag{3.24}$$

The equilibrium condition on the final goods market writes is defined by the aggregation of the demand function from final goods producers, $\mathcal{G}\left(Y_{i,t}\left(i\right)\right) = Y^d_{i,t}\mathcal{G}\left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_P}$ where $\mathcal{G}\left(Y_{i,t}\left(i\right)\right) = e^{\varepsilon^A_{i,t}}\mathcal{G}\left(K_{i,t}\left(i\right)^{\alpha} H^d_{i,t}\left(i\right)^{1-\alpha}\right)$ is the aggregation of intermediate goods suppliers and $Y^d_{i,t}$ is the resources constraint. Thus, replacing the demand functions of foreign and home goods (consumption and investment), we finally obtain the home final goods market equilibrium in the home country:

$$\begin{aligned} \frac{Y_{c,t}}{\Delta^P_{c,t}} &= \left(1-\alpha^C_c\right)\left(\frac{P_{c,t}}{P^C_{c,t}}\right)^{-\mu} C_{c,t} + \left(1-\alpha^I_c\right)\left(\frac{P_{c,t}}{P^I_{c,t}}\right)^{-\mu} \left(1+AC^I_{c,t}\right) I_{c,t} \\ &+ \frac{n-1}{n}\left(\alpha^C_p\left(\frac{P_{c,t}}{P^C_{p,t}}\right)^{-\mu} C_{p,t} + \alpha^I_p\left(\frac{P_{c,t}}{P^I_{p,t}}\right)^{-\mu}\left(1+AC^I_{p,t}\right) I_{p,t}\right) \\ &+ G_{c,t} + AC^D_{c,t}, \end{aligned} \tag{3.25}$$

where $\Delta^P_{i,t} = \mathcal{G}\left(P_{i,t}\left(i\right)/P_{i,t}\right)^{-\epsilon_P}$ denotes the price dispersion term, which is induced by the assumed nature of price stickiness, is inefficient and entails output loss. To close the model, adjustment costs on deposits are entirely home biased:

$$AC^D_{i,t} = \mathcal{G}(AC^D_{i,t}\left(i\right)^{\frac{(\epsilon_P-1)}{\epsilon_P}})^{\frac{\epsilon_P}{(\epsilon_P-1)}},$$

the associated demand function writes, $AC^D_{i,t}(i) = (P_{i,t}(i)/P_{i,t})^{-\epsilon_P} AC^D_{i,t}$.

4.6.2 Loan Market

Concerning the equilibrium on loan market, it is defined by the aggregate demand function from retail banks, $\mathcal{G}\left(L^s_{i,t+1}(b)\right) = \Delta^L_{i,t} L^d_{i,t+1}$, where $\Delta^L_{i,t} = \mathcal{G}\left(r^L_{i,t}(b)/r^L_{i,t}\right)^{-\epsilon_L}$ is the credit rate dispersion term and $L^d_{i,t+1}$ is the aggregate demand from home and foreign entrepreneurs, and is defined by, $L^d_{i,t+1} = \mathcal{G}(L_{h,i,t+1}(e)) + \mathcal{G}(L_{f,i,t+1}(e))$. Recalling that entrepreneurs e borrow to domestic and foreign banks with varieties b produced by wholesale branches, the equilibrium finally writes in the home country:

$$L^s_{c,t+1} = \left(\left(1-\alpha^L_c\right)\left[\frac{r^L_{c,t}}{p^L_{c,t}}\right]^{-\nu} L_{c,t+1} + \frac{n}{n-1}\alpha^L_f \left[\frac{r^L_{c,t}}{p^L_{p,t}}\right]^{-\nu} L_{p,t+1}\right)\Delta^L_{c,t}. \tag{3.26}$$

Aggregate loan rate index evolves according to:

$$\left(r^L_{i,t}\right)^{1-\epsilon_L} = \theta^L_i \left(r^L_{i,t-1}\right)^{1-\epsilon_L} + \left(1-\theta^L_i\right)\left(r^L_{i,t}\right)^{1-\epsilon_L}. \tag{3.27}$$

4.6.3 Deposit Market

Eventually the equilibrium on deposit market is defined by the aggregate demand for deposits services of households and the aggregate supply from deposit packers. Aggregating the demand function from deposit packers leads to the equilibrium on this market, $\mathcal{G}(D_{i,t+1}(b)) = \Delta^D_{i,t}\mathcal{G}\left(D^d_{i,t+1}(j)\right)$, where $\Delta^D_{i,t} = \mathcal{G}(r^D_{i,t}(b)/r^D_{i,t})^{-\mu^D_{i,t}/(\mu^D_{i,t}-1)}$ is the interest rate dispersion term, while the aggregate deposit rate index evolves according to:

$$\left(r^D_{i,t}\right)^{\frac{1}{1-\mu^D_{i,t}}} = \theta^D_i \left(r^D_{i,t-1}\right)^{\frac{1}{1-\mu^D_{i,t}}} + \left(1-\theta^D_i\right)\left(r^D_{i,t}\right)^{\frac{1}{1-\mu^D_{i,t}}}. \tag{3.28}$$

5 Estimation

5.1 Data

We split the Eurozone in two groups: core and periphery. Since EMU creation, countries with current account surpluses belong to the core country group, other countries belong to the peripheral group[20]. France is halfway since its current account had been

[20] Core countries: Austria, Belgium, Germany, Finland, France, Luxembourg and the Netherlands. Peripheral countries: Spain, Greece, Ireland, Italy and Portugal.

positive from 1999 to 2003, we make the hypothesis that France is still a core country despite its recent current account deficits[21]. The model is estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q3, which makes 59 quarterly observations for each variable (except for financial variables). The dataset includes 15 times series: real GDP (Eurostats), real consumption (Eurostats), real investment (Eurostats), the ECB refinancing operation rate (Eurostats, one year maturity), the HICP (ECB, overall index, deseasonalized using a multiplicative decomposition), the overnight deposit rate of households and firms (ECB), the outstanding amount of loan and lending rate to non-financial corporations (ECB, 2003-2013, deseasonalized using a multiplicative decomposition). Data with a trend are made stationary using a linear trend and are divided by the population. We also demean the data because we do not use the information contained in the observable mean. Figure 3.3 plots the transformed data.

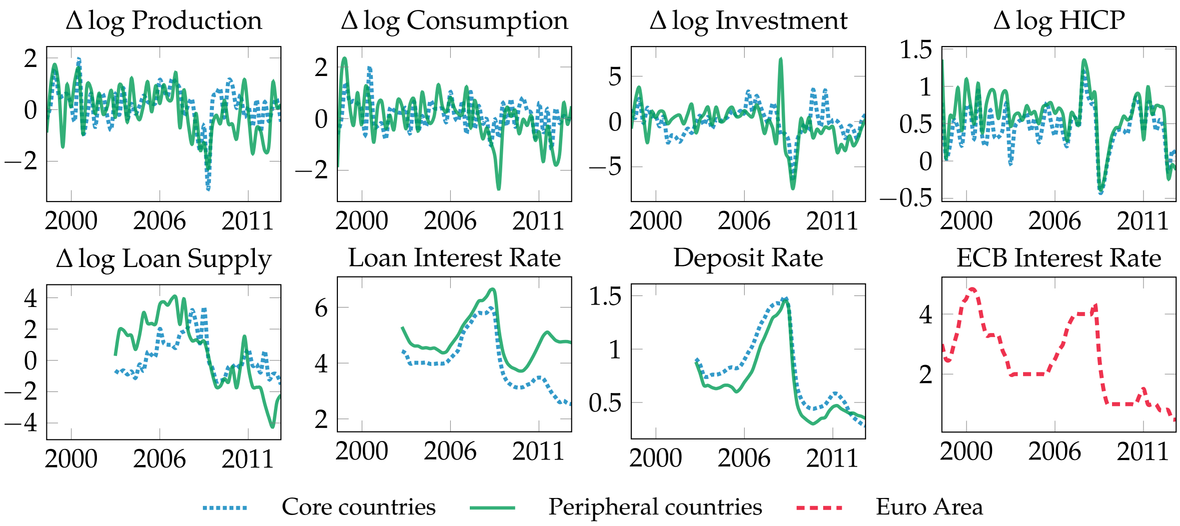


FIGURE 3.3: Observable variables

5.2 Calibration and Priors

The complete set of calibrated parameters is reported in Table 3.2. We fix a small number of parameters commonly used in the literature of real business cycles models[22]: these include β the discount factor, δ the quarterly depreciation rate, α the capital

[21] Quint & Rabanal (2013) use the same assumption, there are reasons that justify this choice. The French government bond yield remains at very low levels, house prices and the credit-minus-refinancing spread for firms remained quite stable during the financial crisis episode.

[22] The Euro area was created in 1999, so our sample is relatively short, following Smets & Wouters (2007) we calibrate rather than estimate structural parameters which are known to be weakly identified (we do not estimate parameters that determine the steady state of the model).

Parameter	Value	Description
β	0.99	Discount factor
δ	0.025	Depreciation rate
α	0.36	Capital share
$\bar{H}$	1/3	Steady state hours worked
ϵ_P	10	Substitution between varieties
$\bar{r} - \bar{r}^D$	1.5/400	Refinancing rate minus the deposit rate
$\bar{r}^L - \bar{r}^D$	4.3/400	Credit rate minus the deposit rate
$\bar{G}/\bar{Y}$	0.24	Government expenditures to GDP ratio
$\bar{N}/\bar{K}$	0.3	Net worth to capital ratio
$\bar{D}/\bar{L}$	0.46	Deposit to loan ratio
$\overline{BK}/\bar{L}$	0.11	Bank capital to loans ratio
μ^B	0.12	Auditing costs
$1 - \eta$	0.025/4	Insolvency share of investment projects
n	0.65	Share of core countries in total EMU

Table 3.2: Calibration of the model (all parameters are on a quarterly basis)

share in the production and $\bar{H}$ the share of steady state hours worked. The government expenditures to GDP ratio is set at 24%[23]. Concerning ϵ_P the substitutability between final good varieties, it is calibrated as in Smets & Wouters (2007) at 10 which roughly implies a markup of 11%. Regarding financial parameters, we fix $\bar{N}/\bar{K}$ the net worth to capital ratio of entrepreneur as in Gerali et al. (2010). The steady state value of spreads ($\bar{r} - \bar{r}^D$ and $\bar{r}^L - \bar{r}^D$) and the bank balance sheet ($\bar{D}/\bar{L}$ and $\overline{BK}/\bar{L}$) are calibrated on their average values observed in the data. The annual share of insolvent entrepreneurs' projects $1 - \bar{\eta}^E$ is fixed at 2.5% and the quarterly cost of audit μ^B is 0.12, those values are comparable to Bernanke et al. (1999), Hirakata et al. (2009) or Christiano et al. (2009). Following Kolasa (2009), we set the parameter governing the relative size of the core area n to 65%, which is the share implied by nominal GDP levels averaged over the period 1999-2013.

Our priors are listed in Table 3.3. Overall, they are either relatively uninformative or consistent with earlier contributions to Bayesian estimations. For a majority of new Keynesian models' parameters, *i.e.* σ_i^C,. σ_i^L, h_i^C, θ_i^P, ξ_i^P, χ_i^I, ϕ^π, $\phi^{\Delta y}$ and shocks processes parameters, we use the prior distributions close to Smets & Wouters (2003, 2007) and Kolasa (2009). Calvo probabilities are assumed to be around 0.50 for prices, credit rates and deposit rates, which are quite uninformative and rely largely on Smets & Wouters (2003, 2007) and Darracq-Pariès et al. (2011). Concerning international macroeconomic parameters, our priors are inspired by Lubik & Schorfheide (2006): for the final goods market openness α_i^C and α_i^I, we choose a beta prior of mean 0, 12 and 0.05

[23]On average, Euro Area households consumption represents 56% of the GDP and investment 20%, then the exogenous spending-GDP ratio is straightforward to derive.

of standard deviation[24], while for the credit market openness we choose 0.50 and 0.20 for prior distribution[25]. At last substituabilities between home/foreign credit and final goods are set to 1.50 with standard deviations of 0.50. We set the prior for the elasticity of the external finance premium $\varkappa_i$ to a beta distribution with prior mean equal to 0.05 and standard deviation 0.02 consistent with previous financial accelerator estimations (Gilchrist, Ortiz, & Zakrajsek, 2009; Bailliu et al., 2012). Adjustment cost on deposits χ_i^D is supposed to fluctuate around 0.0007 with a standard deviation of 0.0004, this prior is compatible with the findings of Schmitt-Grohé & Uribe (2003). Finally, in order to catch up the correlation and co-movement between countries' aggregates, we estimate the cross-country correlation between structural shocks. Our priors are inspired by in Jondeau et al. (2006) and Kolasa (2009), we set the mean of the prior distribution for the shock correlations between core countries and peripheral countries to 0 with a large standard deviation of 0.40.

5.3 Posteriors and Fit of the model

The methodology is standard to the Bayesian estimations of DSGE models[26]. Table 3.3 (page 83) reports the prior and posterior distributions of the parameters of the model. Overall, all the estimated structural parameters are mostly significantly different from zero. Comparing our estimates of deep parameters with the baseline of Smets & Wouters (2003) for the Euro Area, we find higher standard deviations for all the shocks, this mainly comes from the 2007 financial crisis captured by our model as strong negative productivity and demand shocks followed by persistent financial shocks (see the decomposition of investment growth in Figure 3.4 page 85 for further details). Concerning the parameters characterizing the investment adjustment cost, consumption habits, labour disutility and the weight on output growth, our estimates are also very close to

[24]The intra-zone openness is calculated by Eyquem & Poutineau (2010) at $\alpha_h^I = \alpha_f^I = 0.04$ and $\alpha_h^C = \alpha_f^C = 0.09$. Ours priors are chosen to be near these values.

[25]The prior for α_i^L is less informative than for α_i^C and α_i^I because Ueda (2012) suggests that credit market intrazone openness is around 0.35 in the Eurozone. Then a prior distribution with a mean 0.12 would be too much opinionated.

[26]Interest rates data are annualized, we take into account this maturity by multiplying by 4 the rates in the measurement equation. The number of shocks and observable variables are the same to avoid stochastic singularity issue. Recalling that $i \in \{h, f\}$, the vectors of observables $\mathcal{Y}_t^{obs} = [\Delta \log \hat{Y}_{i,t}, \Delta \log \hat{C}_{i,t}, \Delta \log \hat{I}_{i,t}, r_t, \pi_{i,t}^c, \Delta \log \hat{L}_{i,t}^s, r_{i,t}^L, r_{i,t}^D]'$ and measurement equations $\mathcal{Y}_t = [\hat{y}_{i,t} - \hat{y}_{i,t-1}, \hat{c}_{i,t} - \hat{c}_{i,t-1}, \hat{\imath}_{i,t} - \hat{\imath}_{i,t-1}, 4\hat{r}_t, \hat{\pi}_{i,t}^c, \hat{l}_{i,t}^s - \hat{l}_{i,t-1}^s, 4\hat{r}_{i,t}^L, 4\hat{r}_{i,t}^D]'$, where Δ denotes the temporal difference operator, $\hat{X}_t$ is per capita variable of X_t and $\hat{x}_t$ is the loglinearized version of X_t. The model matches the data setting $\mathcal{Y}_t^{obs} = \overline{\mathcal{Y}} + \mathcal{Y}_t$ where $\overline{\mathcal{Y}}$ is the vector of the mean parameters, we suppose this is a vector of all 0. The posterior distribution combines the likelihood function with prior information. To calculate the posterior distribution to evaluate the marginal likelihood of the model, the Metropolis-Hastings algorithm is employed. We compute the posterior moments of the parameters using a sufficiently large number of draws, having made sure that the MCMC algorithm converged. To do this, a sample of 250,000 draws was generated, neglecting the first 50,000. The scale factor was set in order to deliver acceptance rates of between 20 and 30 percent (The acceptance ratio per chains: 26.22% and 26.28%). Convergence was assessed by means of the multivariate convergence statistics taken from Brooks & Gelman (1998). We estimate the model using the dynare package of Adjemian et al. (2011).

		Prior distributions			Posterior distribution *[5%:95%]*			
		Shape	Mean	Std.	CORE		PERIPHERY	
SHOCK PROCESS AR(1)								
Productivity	σ_i^A	$\mathcal{IG}$	0.1	2	0.91	*[0.74:1.07]*	1.25	*[0.99:1.49]*
Gov. Spending	σ_i^G	$\mathcal{IG}$	0.1	2	1.34	*[1.13:1.55]*	2.12	*[1.75:2.47]*
Preferences	σ_i^U	$\mathcal{IG}$	0.1	2	0.67	*[0.50:0.85]*	0.81	*[0.56:1.03]*
Investment Adj. costs	σ_i^I	$\mathcal{IG}$	0.1	2	2.12	*[1.61:2.58]*	2.05	*[1.55:2.55]*
Collateral	σ_i^N	$\mathcal{IG}$	0.1	2	0.20	*[0.11:0.30]*	1.01	*[0.61:1.32]*
External Finance	σ_i^Q	$\mathcal{IG}$	0.1	2	0.41	*[0.28:0.55]*	0.47	*[0.29:0.64]*
Bank Deposit	σ_i^D	$\mathcal{IG}$	0.1	2	0.04	*[0.04:0.05]*	0.05	*[0.04:0.06]*
Monetary Policy	σ^R	$\mathcal{IG}$	0.1	2		0.09	*[0.08:0.11]*	
Productivity root	ρ_i^A	$\mathcal{B}$	0.7	0.10	0.95	*[0.92:0.98]*	0.99	*[0.99:0.99]*
Gov. Spending root	ρ_i^G	$\mathcal{B}$	0.7	0.10	0.81	*[0.73:0.90]*	0.91	*[0.86:0.96]*
Preferences root	ρ_i^U	$\mathcal{B}$	0.7	0.10	0.71	*[0.59:0.83]*	0.64	*[0.48:0.80]*
Investment A.C. root	ρ_i^I	$\mathcal{B}$	0.7	0.10	0.59	*[0.47:0.71]*	0.59	*[0.44:0.72]*
Collateral root	ρ_i^N	$\mathcal{B}$	0.7	0.10	0.61	*[0.40:0.81]*	0.34	*[0.22:0.46]*
External Fin. Prem. root	ρ_i^Q	$\mathcal{B}$	0.7	0.10	0.79	*[0.69:0.88]*	0.78	*[0.69:0.87]*
Bank Deposit root	ρ_i^D	$\mathcal{B}$	0.7	0.10	0.70	*[0.62:0.78]*	0.70	*[0.60:0.80]*
Monetary Policy root	ρ^R	$\mathcal{B}$	0.7	0.10		0.40	*[0.30:0.50]*	
Spending-Productivity	ρ_i^{ag}	$\mathcal{B}$	0.8	0.05	0.82	*[0.74:0.90]*	0.81	*[0.73:0.89]*
Correlation Productivity	$corr_t^A$	$\mathcal{N}$	0	0.40		0.39	*[0.22:0.57]*	
Correlation Spending	$corr_t^G$	$\mathcal{N}$	0	0.40		0.05	*[-0.17:0.25]*	
Correlation Preferences	$corr_t^U$	$\mathcal{N}$	0	0.40		-0.17	*[-0.40:0.06]*	
Correlation Investment	$corr_t^I$	$\mathcal{N}$	0	0.40		0.28	*[0.08:0.48]*	
Correlation Collateral	$corr_t^N$	$\mathcal{N}$	0	0.40		0.17	*[-0.36:0.85]*	
Correlation EFP	$corr_t^Q$	$\mathcal{N}$	0	0.40		0.02	*[-0.27:0.31]*	
Correlation Deposits	$corr_t^D$	$\mathcal{N}$	0	0.40		0.95	*[0.92:0.98]*	
STRUCTURAL PARAMETERS								
Consumption aversion	σ_i^C	$\mathcal{G}$	1.5	0.20	1.21	*[0.95:1.48]*	1.40	*[1.11:1.68]*
Labour Disutility	σ_i^L	$\mathcal{G}$	2	0.75	1.70	*[0.73:2.64]*	1.25	*[0.52:2.00]*
Consumption Inertia	h_i^C	$\mathcal{B}$	0.7	0.10	0.17	*[0.07:0.27]*	0.38	*[0.27:0.49]*
Calvo Prices	θ_i^P	$\mathcal{B}$	0.5	0.10	0.71	*[0.64:0.78]*	0.62	*[0.52:0.72]*
Indexation Prices	ξ_i^P	$\mathcal{B}$	0.5	0.15	0.17	*[0.05:0.29]*	0.34	*[0.13:0.54]*
Calvo Loan Rates	θ_i^L	$\mathcal{B}$	0.5	0.10	0.49	*[0.41:0.56]*	0.59	*[0.52:0.66]*
Calvo Deposit Rates	θ_i^D	$\mathcal{B}$	0.5	0.10	0.73	*[0.69:0.78]*	0.70	*[0.63:0.76]*
Investment A.C. Cost	$\mathcal{X}_i^I$	$\mathcal{N}$	4	1.5	4.27	*[2.61:5.99]*	5.52	*[3.78:7.18]*
E.F.P. Elasticity	$\varkappa_i$	$\mathcal{N}$	0.05	0.02	0.05	*[0.02:0.09]*	0.07	*[0.03:0.11]*
Loan Demand	h_i^L	$\mathcal{B}$	0.7	0.10	0.76	*[0.64:0.88]*	0.82	*[0.75:0.89]*
Deposit A.C. cost	$100 \times \chi_i^D$	$\mathcal{N}$	0.07	0.04	0.09	*[0.03:0.15]*	0.11	*[0.05:0.16]*
Final Market Openness	α_i^C	$\mathcal{B}$	0.12	0.05	0.17	*[0.12:0.22]*	0.15	*[0.07:0.22]*
Inv. Market Openness	α_i^I	$\mathcal{B}$	0.12	0.05	0.11	*[0.05:0.17]*	0.13	*[0.06:0.21]*
Credit Market Openness	α_i^L	$\mathcal{B}$	0.5	0.15	0.04	*[0.01:0.08]*	0.39	*[0.26:0.51]*
Substitutability Goods	μ	$\mathcal{G}$	1.5	0.5		2.44	*[2.01:2.85]*	
Substitutability Loans	ν	$\mathcal{G}$	1.5	0.5		1.44	*[1.14:1.74]*	
MPR Smoothing	ρ	$\mathcal{B}$	0.7	0.10		0.16	*[0.08:0.23]*	
MPR Inflation	ϕ^π	$\mathcal{N}$	1.5	0.50		2.37	*[1.94:2.81]*	
MPR GDP	$\phi^{\Delta y}$	$\mathcal{N}$	0.125	0.05		0.85	*[0.83:0.89]*	
Marginal log-likelihood							-574.36	

TABLE 3.3: Prior and Posterior distributions of structural parameters and shock processes.

Note: $\mathcal{IG}$ denotes the Inverse Gamma distribution, $\mathcal{B}$ the Beta, $\mathcal{N}$ the Normal, $\mathcal{G}$ the Gamma.

Smets & Wouters (2003). Turning to the degree of price stickiness, the monetary policy smoothing and the weight on inflation, our posterior distributions are close to the estimates of Christiano et al. (2010). Finally, we find evidence that only two cross-country correlations are significant: productivity and deposit cost-push shocks.

The main differences between core and peripheral countries explain the divergence of business cycles since the creation of the EMU. The gap between core and periphery originates from both shocks and structural parameters. The estimated standard deviation of shocks is larger in peripheral countries. The persistence of shocks is similar between countries except for the collateral shock: entrepreneurs net wealth in peripheral countries experience large and volatile innovations. The disynchronization of the business cycles are also driven by price and rate stickiness, capital demand habits and investment adjustment costs. The diffusion of monetary policy is not symmetric, particularly for the credit market where the rate stickiness is more important in the peripheral area than in the core one.

Concerning the home bias in the consumption and investment baskets of households and capital producers, the model slightly overestimates the openness of the goods market compared to the findings of Eyquem & Poutineau (2010). The estimation of the credit market openness is interesting, as underlined by Brunnermeier et al. (2012), cross-border banking within the euro area experienced explosive growth, especially after around 2003, helping to fuel property booms in Ireland and southern European countries. The model captures this feature as the degrees of openness of the credit market in peripheral countries is 39% and 4% in core countries[27].

To assess how well the model fits the data, we present in Table 3.4 and in Figure 3.6 (page 88) the second moments of the observable variables and their counterpart in the model. The model does reasonably well in explaining the standard deviation of all variables except for deposit rates, despite allowing for different degrees of nominal rigidities via the introduction of Calvo contracts. Nevertheless, the model captures well the persistence of all aggregates except for consumption in the core area. Our model incorporates an imperfect credit market with real rigidities, this way the model does a good job in predicting the standard deviation and persistence of investment and credit in both area. Concerning the cross-country correlations, the model does reasonably well in capturing the co-movement of all aggregates, however it underestimates the cross-country correlation between home and foreign output and investment.

[27]This financial market openness is at odds with the data as it is overestimated in the fit exercise, but it helps in catching co-movements in the credit and investment cycles between core and peripheral countries.

	2nd Moments - Standard Deviation						
	$\Delta Y_{i,t}$	$\Delta C_{i,t}$	$\Delta I_{i,t}$	$\Delta L^s_{i,t}$	$\pi^C_{i,t}$	$R^L_{i,t}$	$R^D_{i,t}$
Empirical - core	0.78	0.60	1.66	1.25	0.30	1.00	0.36
Theoretical - core	0.72	0.68	1.68	1.50	0.42	1.28	0.78
Empirical - periphery	0.94	0.91	2.08	2.25	0.36	0.76	0.34
Theoretical - periphery	0.86	0.91	1.92	2.31	0.45	1.57	0.82

Table 3.4: Empirical and Theoretical Standard deviations

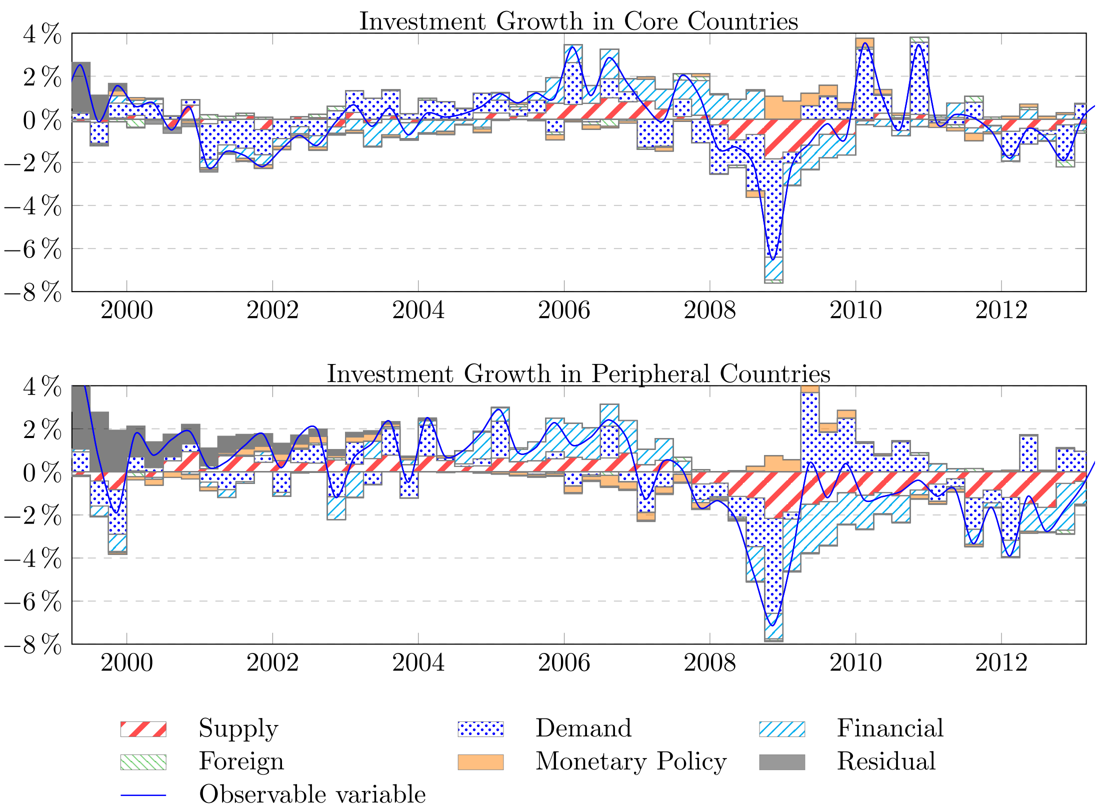


Figure 3.4: Historical contributions to Investment (year-on-year % change generated by the model).

Note: The solid blue line depicts the quarterly growth rate in real investment (per capita) expressed in percentage point deviations from the model's steady state. The colored bars depict the estimated contributions of the various groups of shocks (Supply: home productivity; Demand: home public spending, home preferences & investment adjustment costs; Financial: home external finance premium, deposit cost push & net worth; Foreign: previously mentioned foreign shocks; Moneraty Policy: shock in the ECB taylor rule).

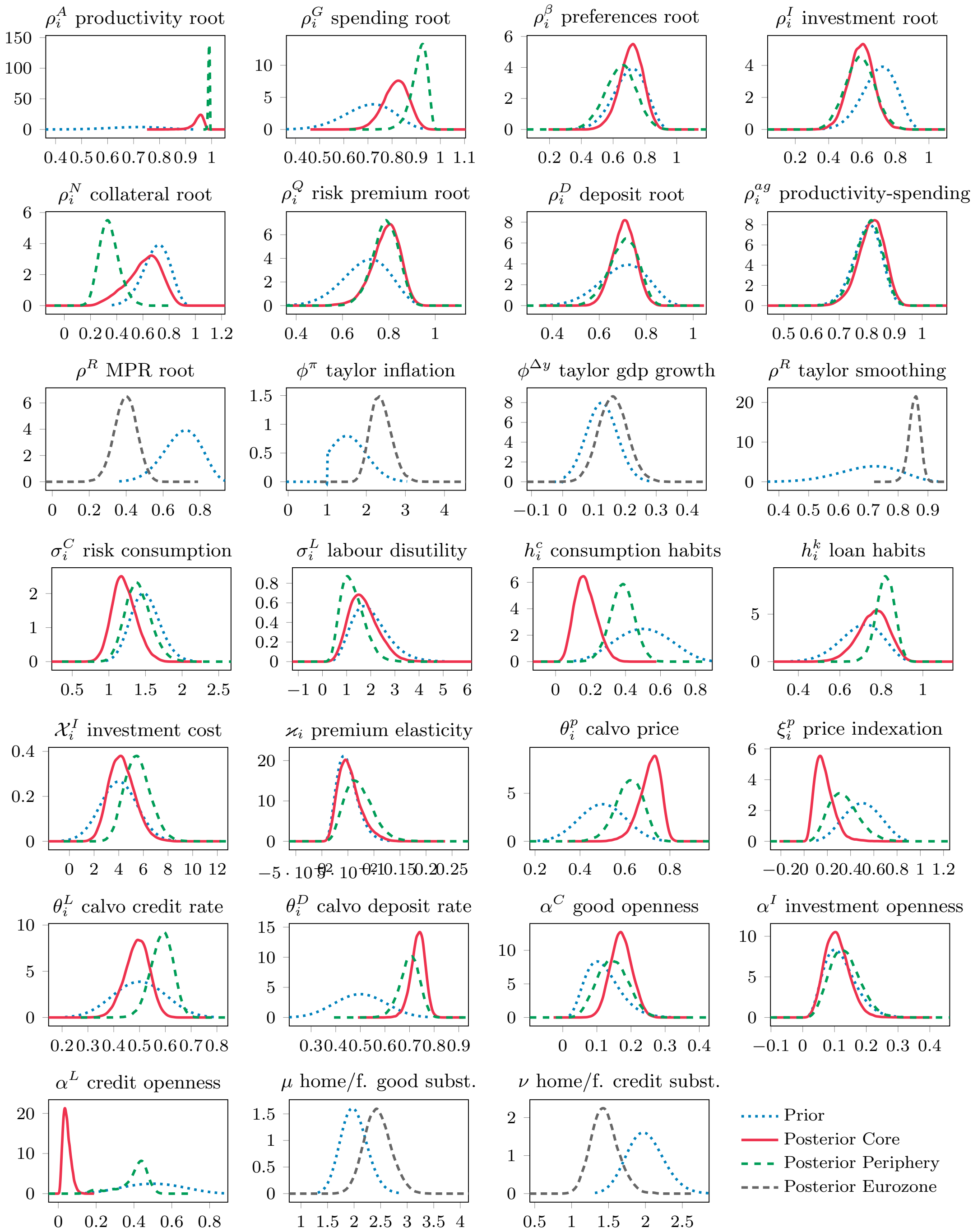


FIGURE 3.5: Prior and posterior distributions of parameters.

6 The Ranking of Alternative Macroprudential Schemes

6.1 The Welfare Performance of Alternative Macroprudential Schemes

The welfare comparison of implementation schemes is based on a second order approximation of household utility function combined with the equilibrium conditions of the model[28]. We compute the per capita federal level welfare increase with respect to the benchmark of the optimal monetary policy[29]. Results are reported in Table 3.5 (page 91).

Monetary policy: The first three rows of the table concentrate on monetary policy by contrasting the estimated, the optimal and the extended monetary policy rule that account for macroprudential concerns. As in Quint & Rabanal (2013), the optimized coefficients of the estimated Taylor rule suggest stronger responses to Euro Area CPI inflation than the estimated coefficients. The optimal monetary policy result will serve as a benchmark in the rest of this section to compute the welfare increase coming for the implementation of macroprudential policy in the participating countries. The empirical rule implies a decrease in welfare representing 0.012% of permanent consumption in the monetary union. As observed, core countries are more affected by a lower concern of authorities on inflation than the periphery (the decrease of permanent consumption by 0.028% is around four times the decrease observed in the periphery). Regarding the macroeconomic side, the optimal rule clearly reduces the standard deviation of inflation but has no impact on real aggregates (the standard deviation of output and business synchronization between Eurozone's countries are unaffected). Finally accounting for macroprudential concerns in the conduct of monetary policy in the extended rule has no noticeable effect on welfare with respect to the optimal Taylor rule: all welfare gains have already been obtained by the optimal setting of the authorities reaction to inflation and output gap development.

This result is in line with Suh (2014): an institutional design is required to separate macroprudential policy from monetary policy since macroprudential considerations in the conduct of monetary policy does not affect welfare in the monetary union (with

[28] In the quantitative simulation, we first search for weights attached to inflation ϕ^{π} and GDP growth $\phi^{\Delta y}$ in the Taylor rule that gives the highest unconditional welfare of households from Equation 3.18. Here, we maintain the autoregressive parameter of the policy rule ρ^{R} at its estimated value since it has low effects on welfare. Based on the grid search by 0.01 unit, we limit our attention to policy coefficients in the interval $(1,3]$ for ϕ^{π}, $[0,3]$ for $\phi^{\Delta y}$ (Schmitt-Grohé & Uribe, 2007), and in the interval $[0,3]$ for macroprudential instruments ϕ_h and ϕ_f.

[29] We consider that the monetary authorities are concerned by the union-wide welfare, $\mathcal{W}_{u,t} = n\mathcal{W}_{h,t} + (1-n)\,\mathcal{W}_{f,t}$. Following Adjemian et al. (2008) and Woodford (2003), we account for the lower bound by adding to the welfare index a term penalizing the nominal deposit rate variance $\lambda_R \left(r^D_{u,t} - \bar{r}^D_u\right)^2$ where $\lambda_R = 0.077$ (Woodford, 2003).

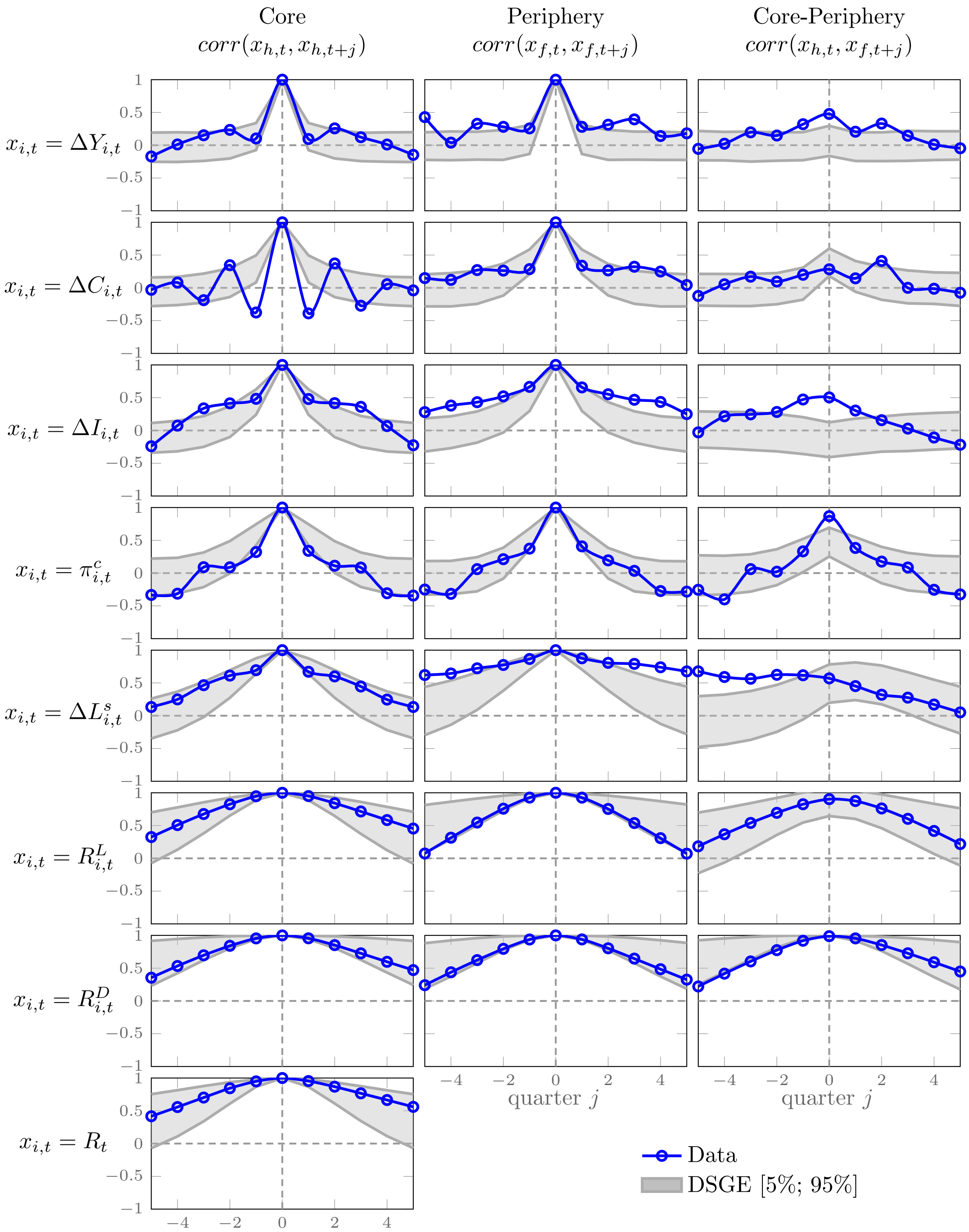


FIGURE 3.6: Dynamic correlations of the main variables: observable variables (blue) and 90% confidence band interval generated by the estimated model centered around the asymptotic mean

respect to the optimal rule). This result reassesses the complementarity of Macroprudential and monetary policy. These two instruments should remain separated: a credit growth adjusted Taylor rule does not increase welfare according to our calculations.

Macroprudential policy reacting to federal loan developments: The first set of macroprudential policies reported in rows 4 and 5 react to the aggregate evolution of loans in the Eurozone (namely the average per capita level of loans contracted in the monetary union). We distinguish a uniform reaction imposed to all participating countries in row 4 with an heterogeneous reaction (in which macroprudential policy parameter are set at the regional level, so as to distinguish core and peripheral situations) in row 5. As reported by "Global 1" rule, the homogenous reaction to federal developments leads to a negligible welfare improvement (representing 0.004% of permanent consumption). The financial stress observed for peripheral countries is diluted at the federal level and the low value obtained for the macrorpudential parameter ($\phi = 0.06$), has almost no consequence on the building of financial disequilibrium in the periphery of the monetary union.

The heterogenous treatment of regions leads to a stronger reaction of macroprudential policy in the peripheral countries. Now the penalty parameter is set at $\phi_f = 3$ (the maximum value) in the periphery while there is no reaction of macroprudential policy in the core countries. On federal grounds, this solution is optimal as it leads to the highest increase in Union Wide per capita welfare average (representing an increase 0.3330% of permanent consumption for a representative agent of the Eurozone). This solution accounts for externalities coming from the cross-border loans but is also able to correct regional financial imbalances. However, this policy is not a free lunch: peripheral countries benefit from a high increase of welfare (representing 0.789% of permanent consumption which is the highest figure reported in the table) while the welfare of core countries slightly decreases (by 0.0397% of permanent consumption) with respect to the implementation of the optimal monetary policy.

Macroprudential policy reacting to national loan developments: The two solutions reported in rows 6 and 7 assume an homogenous reaction to national lending developments. To account for the possibility of banks to engage in cross-border lending, we contrast two situations focussing on the regional supply or demand of loans. In both situations, we impose a common setting of the macroprudential policy stance parameter on national financial developments. As observed, imposing a uniform treatment of countries leads to rather small welfare gains (between 0.0028 and 0.0093% of permanent consumption) at the federal level and in both cases creates welfare losses for the core countries, with respect to the conduct of an optimal monetary policy. As underlined, concentrating on borrowers implies a higher penalty parameter for macroprudential policy in the Eurozone.

Granular solutions: Finally, the last two situations reported in rows 8 and 9 account for a granular implementation of macroprudential policies. Namely, Macroprudential policy is tailored to the regional level situation. It takes into account regional developments and the macroprudential penalty parameter is heterogenous in each part of the monetary union. In this situation, the targeting of loan supply (*i.e.*, concentrating on financial intermediaries rather then on the borrowers) is the best policy. This solution is the only one that implies welfare gains at both the federal and regional levels. In this situation welfare increases in the two regions, even if the permanent consumption increase is much higher in the periphery than in the core (0.4953% instead of 0.0024%). It thus presents some particular features: it is not the Pareto optimal situation in the Eurozone but it does not create regional welfare losses with respect to the conduct of an optimal in peripheral countries In contrast, as reported by "Granular 2" rule, assuming that national authorities are able to react to the amount of loans contracted by entrepreneurs (*i.e.*, they take macroprudential measures with respect to the amount of loans that is provided in their economy by both domestic and foreign banks), the union per capita consumption increases by 0.055%. This increase in the federal per capita level of permanent consumption combines a net increase of per capita permanent consumption of 0.01384% in core countries and a decrease of per capita permanent consumption of 0.04621 % in the periphery). As reported, the main difference between the two implementation scheme should be linked to the value of the macroprudential parameter for the periphery which is much higher (3.00 instead of 2.44) when authorities account for the decisions of the banking system with respect to "Granular 1" rule.

Results reported in Table 3.5 clearly distinguish two situations of interest. First, the reaction to federal development with parameters set at the regional level is Pareto optimal in the monetary union. However, this situation clearly implies a decrease in core county welfare with respect to an optimal monetary policy without macroprudential concerns. This result is in line with Jeanne & Korinek (2013). Since authorities have to find the best balance between national and federal levels in implementing the macroprudential framework, it is not surprising that the greater welfare gains are recorded for the coordination scheme that combines the federal decision step (to account for externalities) with national implementation schemes (to account for the national nature of financial cycles). Second, in contrast, a granular solution reacting to regional loan creation (*i.e.*, taking into account the financial sector rather than borrowers) developments with parameters set at the regional parameters lead to lower welfare gains at the federal level but implies regional welfare gains in the two parts of the monetary union.

	Monetary Policy		Macroprudential Policy		Unconditional Consumption Gains (%)			Macroeconomic Performances			Business Synchronization
	ϕ^{π}	$\phi^{\Delta y}$	$\phi_c^{\mathcal{MP}}$	$\phi_p^{\mathcal{MP}}$	Union	Core	Periph.	sd$(\pi_{u,t})$	sd$(\Delta y_{u,t})$	sd$(\Delta L^s_{u,t})$	corr$(\Delta y_{c,t}, \Delta y_{p,t})$
Estimated Rule	2.37	0.16	-	-	-0.012	-0.028	0.008	0.44	0.74	1.71	0.34
Optimal Rule	2.79	0	-	-	-	-	-	0.40	0.75	1.71	0.35
Federal											
Federal 1 (taylor)	2.79	0	0		0	0	0	0.40	0.75	1.71	0.35
Federal 2	2.93	0	0.06		0.004	-0.004	0.015	0.40	0.74	1.68	0.35
Federal 3 (cooperation)	2.42	0	0	3	0.332	-0.037	0.784	0.44	0.75	4.24	0.35
National											
National 1 (supply)	2.82	0	0.06		0.0028	-0.0066	0.0144	0.40	0.74	1.46	0.35
National 2 (demand)	2.88	0	0.14		0.0093	-0.017	0.0415	0.39	0.74	2.65	0.35
Granular											
Granular 1 (supply)	2.66	0	0.02	3	0.223	0.005	0.491	0.41	0.75	1.35	0.36
Granular 2 (demand)	3	0	0	2.44	0.055	0.141	-0.051	0.40	0.75	9.83	0.36
No crossborder											
Empirical rule	2.37	0.16	-	-	-0.0196	-0.0280	-0.0092	0.44	0.74	1.77	0.34
Optimal Rule	3	0	-	-	-	-	-	0.39	0.75	1.78	0.34
Federal											
Federal 1	3	0	0		0	0	0	0.39	0.75	1.78	0.34
Federal 2	3	0	0.07		0.004	-0.001	0.010	0.39	0.75	1.72	0.34
Federal 3 (cooperation)	3	0	0	0.13	0.011	-0.006	0.032	0.39	0.75	1.74	0.34
National											
National 1 (supply)	3	0	0.09		0.010	-0.0083	0.0325	0.39	0.74	1.64	0.35
National 2 (demand)	3	0	0.09		0.010	-0.0083	0.0325	0.39	0.74	1.64	0.35
Granular											
Granular 1 (supply)	3	0	0	0.15	0.018	-0.007	0.048	0.39	0.75	1.67	0.35
Granular 2 (demand)	3	0	0	0.15	0.018	-0.007	0.048	0.39	0.75	1.67	0.35

TABLE 3.5: Welfare-based Performance of Macroprudential Rules

6.2 Macroeconomic Performances

As reported in Table 3.5, the institutional design of macroprudential policy affects the macroeconomic performance of the monetary union.

First, the lowest value for the standard deviation of inflation is obtained with the National 2 rule (0.39). In this situation, the weight associated to inflation in the interest rate is the highest. In the other cases inflation performance is a bit higher (0.40) but lower than with the estimated Taylor rule (0.44). In all cases, the weight affected to the reaction of the central bank interest rate to inflation is lower. Thus it is not related to the specialization of the central bank in the conduct of monetary policy.

Regarding loan developments, we find that the way macroprudential decisions are implemented clearly affects the standard deviation of loans. The best performance is obtained in the situation "Granular1" when macroprudential policy is conducted nationally to target lender decisions. In this case macroprudential policy reacts to the national supply for loans. In contrast, the highest value is observed in scenario "Global 2" when authorities react heterogeneously to federal developments in loan creation.

Finally, we find no evidence of a noticeable real impact of the macroprudential governance scheme on activity in the Monetary union. As reported, the standard deviation of output is around 0.75 under all policy options (with or without macroprudential concerns) while the synchronization of business cycles between core countries and peripheral countries is almost unaffected by the policy option.

6.3 The critical role of cross-border loans

As previously noted, most of the papers devoted to the discussion of macroprudential policy in the Eurozone neglect the reality of cross-border loans as a main component of the regional financial integration. To evaluate the sensitivity of our results to this particular feature of the analysis, we report in the lower part of Table 3.5 welfare gains assuming loan market segmentation ($\alpha_c^L = \alpha_p^L = 0$) between the core and the periphery.[30]

As reported, cross-border lending affects the welfare analysis in a significative way. Thus, neglecting cross-border flows may lead to fallacious results, both in terms of policy reaction and welfare gains. First, welfare gains are much lower without cross-border lending. Without cross-border loans, financial spillovers are smaller and, by so, the permanent consumption increase of macroprudential measures is lower. As observed, segmenting

[30] As a consequence, the two national scenarios of the analysis are the same as national entrepreneurs can only borrow from national banks.

loan markets drastically reduces the macroprudential parameters in the periphery (e.g., now the highest value for the macroprudential policy in the periphery is, $\phi_p^{\mathcal{MP}} = 0.15$ instead of the upper value of $\phi_p^{\mathcal{MP}} = 3.00$ previously). Thus welfare gains are limited to 0.018 of permanent consumption at the union level (instead of an increase representing up to 0.3332% of permanent consumption with cross border lending). Second, the granular solution is now Pareto optimal. However, as reported by the figures the enforceability of macroprudential measures based on the optimization of the joint welfare of core and peripheral countries is difficult to assess. Indeed, without cross-border lending, core countries are always losers, as their welfare decreases with respect to the benchmark of the optimal monetary policy. In contrast peripheral countries are always winners (even if the increase in permanent consumption is much lower than observed with cross-border lending).

Finally, regarding macroeconomic performances, we observe only very slight differences with the international banking situation (there is no real impact on inflation while the standard deviation of activity and business cycle synchronization is slightly lower). The main noticeable difference is observed with respect to the standard deviation of loan growth (that reaches a maximum value of 1.67 now instead of 9.83 in the granular situation).

7 The Impact of Macroprudential Policies: a counterfactual analysis

As broadly defined by the IMF, the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments, so as to avoid periods of widespread distress. As this structural model is amendable to counterfactual analysis as in Carboni et al. (2013), this section discusses how the implementation of macroprudential measures would have performed either task in the Eurozone. In the first counterfactual exercise, we evaluate how the use of macroprudential instruments would have prevented financial problems and affected the volatility of investment during the whole time period of the analysis. In the second counterfactual simulation, we analyze wether such measures would have mitigated the consequences of the recent financial turmoil.

7.1 The preventive impact of a macroprudential policy

We analyze how macroprudential measures could prevent boom-bust dynamics on credit markets. Using the estimated sequence of shocks from 1999 to 2013, we simulate how investment would have evolved in both parts of the monetary union, depending on the

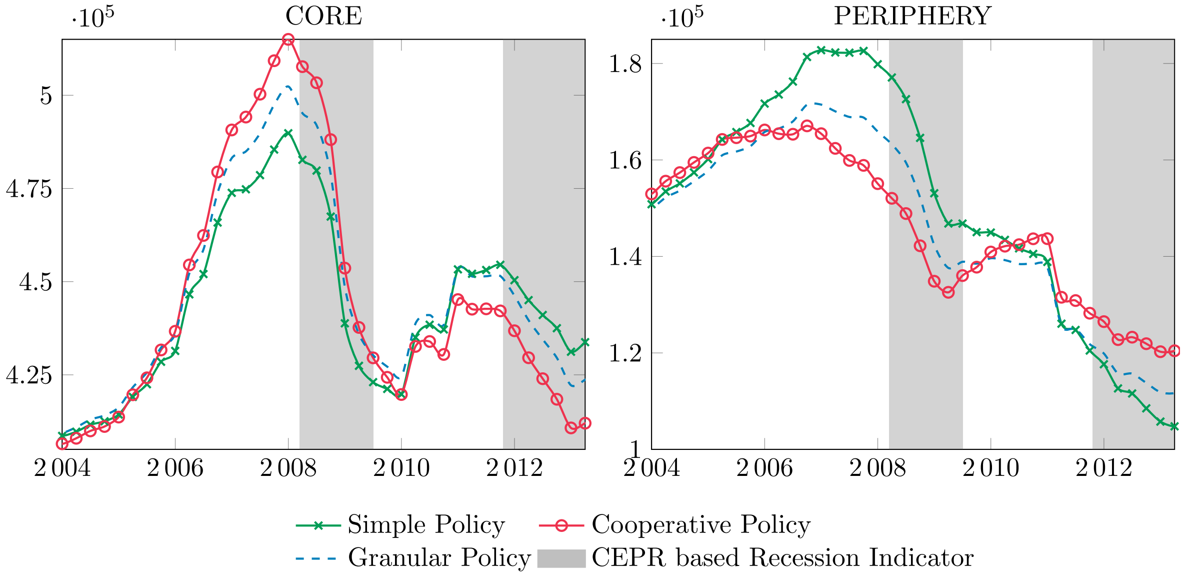


FIGURE 3.7: Counterfactual paths of investment (million euro) under different optimal implementation schemes: no macroprudential policy (green crossed), coordinated macroprudential policy (red circled), Non coordinated macroprudential policy - Host principle (blue dashed) and Non coordinated macroprudential policy - Home principle (black dotted), and the CEPR Recession Indicator for Euro Area Business Cycles (shaded area).

	Simple Rule	Cooperative Scheme	Granular Scheme
std($\Delta\hat{I}_{h,t}$)	1.61	1.83	1.67
std($\Delta\hat{I}_{f,t}$)	1.95	1.64	1.70
std($\Delta\hat{I}_{u,t}$)	1.73	1.77	1.68

Table 3.6: Standard deviation of model generated investment under different implementation schemes

implementation of macroprudential measures. Table 3.6 (page 95) and Figure 3.7 (page 94) display the model's generated investment under the standard monetary policy and compare it with the two most interesting way of implementing macroprudential policy (namely the Pareto optimal situation and the granular solution) as discussed above. This analysis focuses on investment as we previously underlined that credit shocks were the main drivers of investment. As a consequence, macroprudential policy should be assessed with regards to its effects on aggregate investment.

As reported by Figure 3.7, the implementation of macroprudential measures is mainly interesting for peripheral countries, as in this region macroprudential measures have a clear dampening impact on the time path of investment (it clearly reduces the increase in investment up to 2010, while it has an opposite effect after 2010). In contrast, macroprudential measures would have enhanced investment in core countries before the financial crisis. In all cases, the Pareto optimal implementation scheme has the greater impact on the time path of investment, while the granular solution leads to investment fluctuation closer to the ones observed with a simple monetary policy rule.

Overall, our results suggest that leaning against the wind provides macro-financial stability in peripheral countries as it decreases the variance of investment in this region. Comparing the three levels of implementation of macroprudential policy in Table 3.6 the Pareto optimal solution increases the standard deviation of investment at the Union wide level (*i.e.*, the decrease of the standard deviation in the periphery is less than the increase in the standard deviation of investment in the core countries). In contrast, the granular implementation scheme would have contributed to a decrease in the standard deviation in the Eurozone, driven by that of peripheral investment.

7.2 The curative impact of a macroprudential policy

We perform a second counterfactual exercise by simulating the system response to the estimated shock of the financial crisis (2009Q1). We report in Figure 3.8 the IRFs of an aggregated shock as measured by the sum of all shocks that affected each part of the

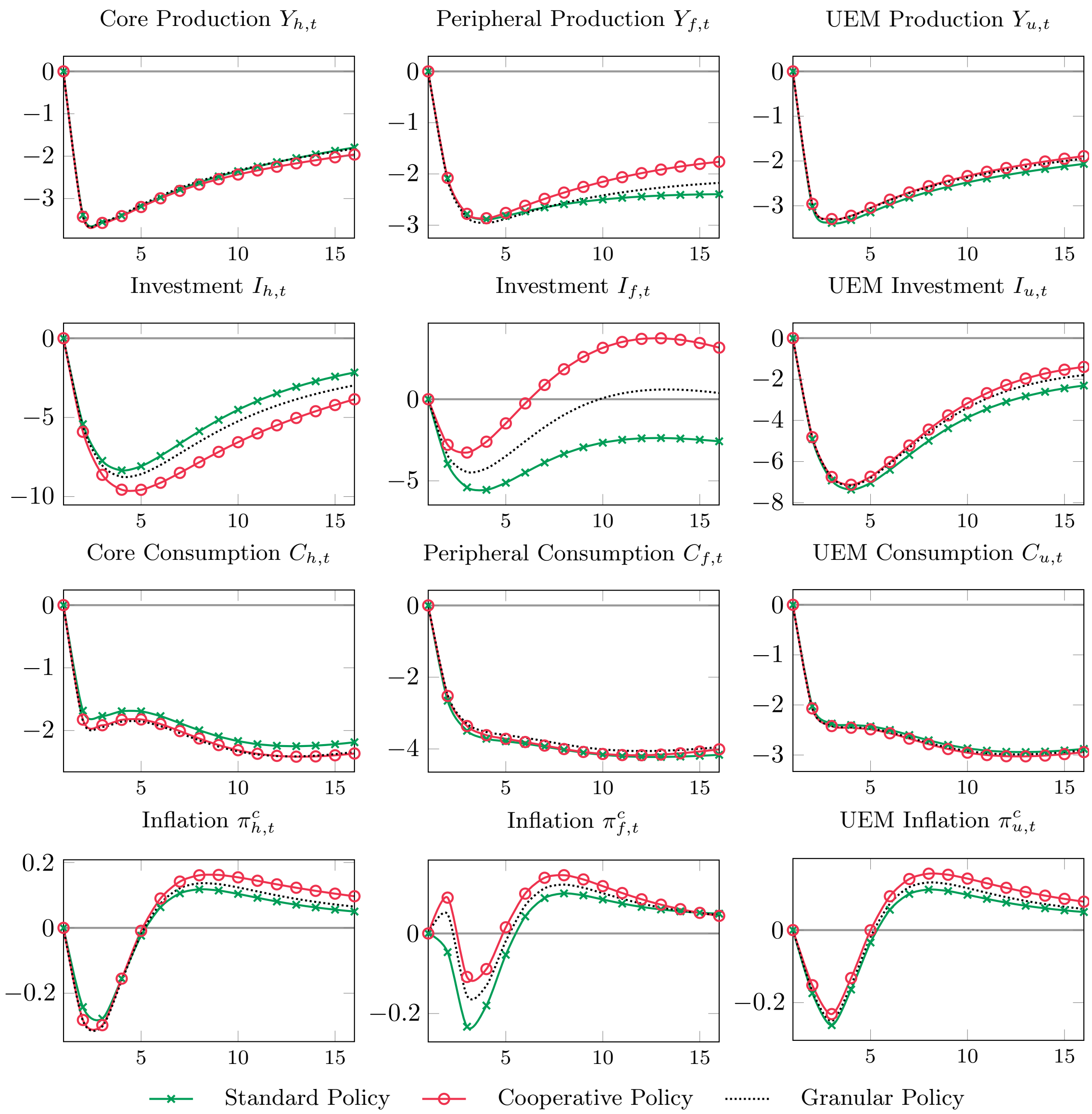


FIGURE 3.8: The financial crisis episode: system response after simulating the financial crisis (2009Q1 shocks) under the optimal policy regime and the optimal coordinated macroprudential policy.

Eurozone in the first quarter of 2009 (taken as the date of the diffusion of the financial crisis in the Eurozone). We then describe the core, periphery and Eurozone responses to this shock, depending on macroprudential policy. We contrast three situations related to the implementation of an optimal Taylor or the implementation of macroprudential measures (along the lines of either the Pareto optimal or granular solutions)[31].

The model catches up the 2009Q1 crisis with a strong reduction in productivity (around -3%), a rise of investment adjustment cost (roughly 6%), a negative spending shock (4%), a collateral crunch shock of 4% in the peripheral countries and an external premium shock of 1% in the two countries.

As shown in Figure 3.8, the impact of macroprudential measures differs across the two parts of the monetary union. We find that macroprudential measures have a different impact on both side on the European union, on activity and investment. In particular, this kind of measure has no impact on core countries' activity while it has a limited impact on activity in the periphery, as it only dampens the negative transmission of the shock after 10 quarters. Concerning investment, the result is more ambiguous. The peripheral investment slow down is reduced by the macroprudential policy and the recovery is clearly increased after 2 periods. These countries clearly benefit from coordinated measures which in turn accelerate investment recovery.

However, we get more ambiguous results for core countries as, in this part of the monetary union, investment drop is surprisingly enhanced by macroprudential policies. This phenomenon can be explained by the fact that the optimized value of the coefficient on inflation ϕ^{π} in the interest rate rule is lower (ϕ^{π} =2.42) with macroprudential policy than without (ϕ^{π} =2.85). In this case monetary authorities react less to deflation under macroprudential measures, which leads to an additional drop in core countries' investment.

The impact of macroprudential measures on consumption is slightly negative in core countries, while it is almost negligible for both the periphery and the monetary union as a whole. In contrast, macroprudential measures have a positive effect on the inflation rate, as they clearly dampen deflation and accelerate the return to a positive rate of inflation. This effect is observed in both regions

8 Conclusion

The aim of this chapter was to measure the welfare gains obtained through the granular implementation of macroprudential measures in the Eurozone. We have built and estimated a two-country DSGE model that includes two key features characterizing

[31]We do not plot the other suboptimal macroprudential policies.

the European banking system: cross-border bank lending and diverging financial cycles between core and peripheral countries. The model has been estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q3.

We find that macroprudential policy increases welfare in the Eurozone depending on the choice of the organizing scheme. Our main results can be summarized as follows: First, Macroprudential policy and monetary policy should be kept separated in the EMU. Second, it is optimal to set macroprudential policy parameters at the regional level since, in all cases, a regional setting of parameters dominates the uniform setting of macroprudential parameters. Third the Pareto optimum equilibrium requires a regional reaction to the union wide rate of loan growth. However, this situation implies a decrease in core county welfare with respect to an optimal monetary policy without macroprudential concerns. In contrast, a granular solution reacting to regional loan creation (i.e., taking into account the financial sector rather than borrowers) developments with parameters set at the regional parameters leads to lower welfare gains at the federal level but implies regional welfare gains in the two parts of the monetary union.

Chapter 4

Cross-border Interbank Loans and International Spillovers in a Monetary Union

1 Introduction

By eliminating currency risk, the adoption of the euro in 1999 generated forces for a greater economic and financial integration. The single currency reshaped financial markets and international investment patterns by enhancing cross-border banking activity between the members of the European Monetary Union (EMU). This phenomenon can be measured along various complementary dimensions such as the increase of FDI in bank activities, the diversification of bank assets and liabilities between countries, the access of local banks to international financial sources or through the increase of banks' lending via foreign branches and direct cross-border lending.

This chapter focuses more specifically on the consequences of the rise in cross-border loan flows observed since the adoption of the Euro in 1999. Cross-border lending is a distinguishing feature of financial integration in the Eurozone:[1] it has been multiplied by 3 in 9 years, before experiencing a 25% decrease after the recent financial crisis. The critical role of cross-border lending in the EMU must be assessed by taking into account the key role of banks in providing the main funding source for households and firms in the euro area: in 2012 the banking sector in the European Union was 4.5 times larger than its US counterpart (respectively 347% of EU GDP and 74% of US GDP). At its peak value in 2008, total cross-border lending represented around 120% of GDP for Eurozone countries, while the corresponding figure was 40% for the US and 20% for

[1]See Figure 4.1 in the text below.

Japan. Taking a closer look at the data, this cross-border phenomenon is heterogenous as it affects mainly interbank lending and corporate lending, while cross-border lending to households is negligible[2]

We develop a two-country DSGE model to document how the transmission of asymmetric shocks in the Eurozone has been affected with a banking system that provides cross-border interbank and corporate lending facilities. This solution is original with respect to the existing literature of monetary policy issues in a monetary union. Indeed, most papers related to this topic can roughly be separated in two strands. On the one hand, one-country models such as Gerali et al. (2010), Darracq-Pariès et al. (2011) and Christiano et al. (2010), assume complete banking integration so that all countries are impacted in the same way by the ECB monetary policy. On the other hand, two-country models such Kollmann et al. (2011) ignore the possibility of cross-border funds. In the meanwhile, the fewer models that adopt a middle of the road solution by assuming an imperfect integration of the loan market (Faia (2007); Dedola & Lombardo (2012); Ueda (2012); Dedola et al. (2013)) do not account for the above mentioned heterogeneity in Eurozone cross-border loan flows.

Our chapter brings theoretical and empirical contributions. To keep the model tractable, we analyze cross-border loans through home bias in the borrowing decisions concerning interbank and corporate loans using CES function aggregates[3]. Cross-border banking flows are introduced analogously to standard trade channel assuming CES function aggregates. This modelling strategy is flexible as it allows to treat in a more compact way two levels of cross-border lending related to interbank loans and corporate loans. The heterogeneity between national financial systems is accounted for through different interest rate set by financial intermediaries. In our setting, bonds are mainly used, as in the intertemporal macroeconomics literature, to allow households to smooth intertemporally consumption and countries to finance current account deficits. Thus, our model does not truly introduce banking but rather reinterpret the financial accelerator from a banking perspective[4].

[2]As underlined by Figure 4.2, European banks mainly finance foreign banks on the interbank market and foreign firms on the corporate credit market while mortgage and deposit markets remain strongly segmented in the Eurosystem.

[3]Home bias in the borrowing decisions catches up some extra costs involved by cross-border activities, such as increasing monitoring costs due to the distance, differences in legal systems and payments, etc. These iceberg costs are closely related to home biais as underlined by Obstfeld & Rogoff (2001).

[4]As a first modelling choice, we do not attempt to model explicitly the balance sheet of the banking system but we try to capture the key elements relevant to our analysis, namely the way the accelerator is affected by cross-border lending. We thus depart from some recent papers where the balance sheet of the banking system lies at the heart of the analysis such as Angeloni & Faia (2013) (that provide an integrated framework to investigate how bank regulation and monetary policy interact when the banking system is fragile and may be subject to runs depending on their degree of leverage) or Gertler & Karadi (2012) (where financial intermediaries face endogenously determined balance sheet constraints to evaluate the effects of unconventional monetary policy decisions to dampen the effect of the financial crisis).

To enhance the empirical relevance of the model we introduce a set of nominal, financial and real rigidities. We estimate the model on quarterly data using Bayesian techniques over a sample time period running from 1999Q1 to 2013Q3. The estimation procedure is implemented by splitting the Eurozone in two groups of countries, the core and the periphery. According to our estimates, we find that accounting for cross-border loans strongly improves the fit of the model.

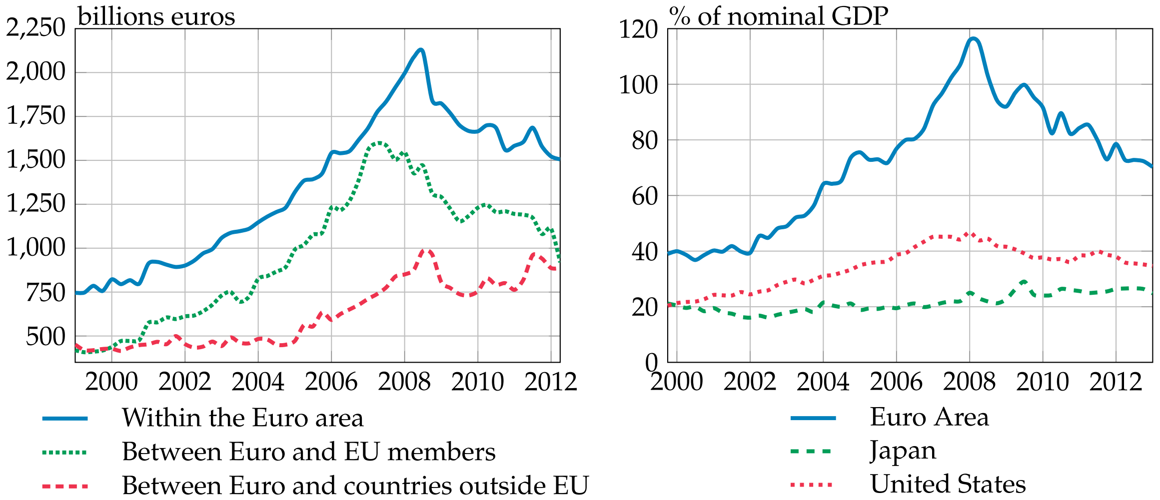
In this setting, we find evidence of the role of cross-border lending channel as an amplifying mechanism for the transmission of asymmetric shocks. First, using Bayesian impulse response functions, we get two main results. In all cases, cross-border lending leads to more diverging investment cycles following either real or financial shocks and, as a consequence, clearly affects the dynamics of the current account with respect to the segmentation of the loan market. Furthermore, cross-border loans amplify the transmission of a negative financial shock on aggregate activity in the Eurozone. Second, an analysis of the historical variance decomposition shows that for most variables cross-border lending has reduced the impact of national financial shocks on national variables while it has increased the effect of financial shocks on the bilateral current account between core and peripheral countries. Third, we perform a counterfactual exercise to evaluate the effect of cross-border banking in the transmission of the financial crisis between the two groups of countries. We find that peripheral countries have been much more affected by the crisis through a deeper impact on interbank loan shortage and that the degree of cross-border banking affects the time path of the main national macroeconomic indicators.

The rest of the chapter is organized as follows: Section 2 presents some stylized facts and a quick summary of the related literature. Section 3 describes the financial component of model. Section 4 presents the real component of the model. Section 5 presents the data and the econometric method. Section 6 uses Bayesian IRFs to evaluate the consequences of cross-border bank lending on the transmission of asymmetric real and financial shocks. Section 7 provides a quantitative evaluation of the consequences of cross-border flows on the volatility of representative aggregates. Section 8 concludes.

2 Stylized Facts and Related Literature

2.1 Cross-border lending in the Eurozone

Cross-border lending is a distinguishing feature of financial integration in the Eurozone. As reported in panel (a) of Figure 4.1, between 1999Q1-2012Q1, cross-border loans have increased much more between participating counties than between the Eurozone and the European Union, and even much more than with countries outside Europe. The rise in cross-border loans is peaking in 2008, where cross-border loans represented 300% of the value initially observed in 1999. The financial crisis is characterized by a 25% drop in cross-border lending between Euro partners. As underlined in panel (b), in 2008, cross-border lending represented around 120% of GDP for Eurozone countries at its peak value, while the corresponding figures were 40% for the US and 20% for Japan. However, a closer view at the data underlines the heterogeneity of bilateral flows within



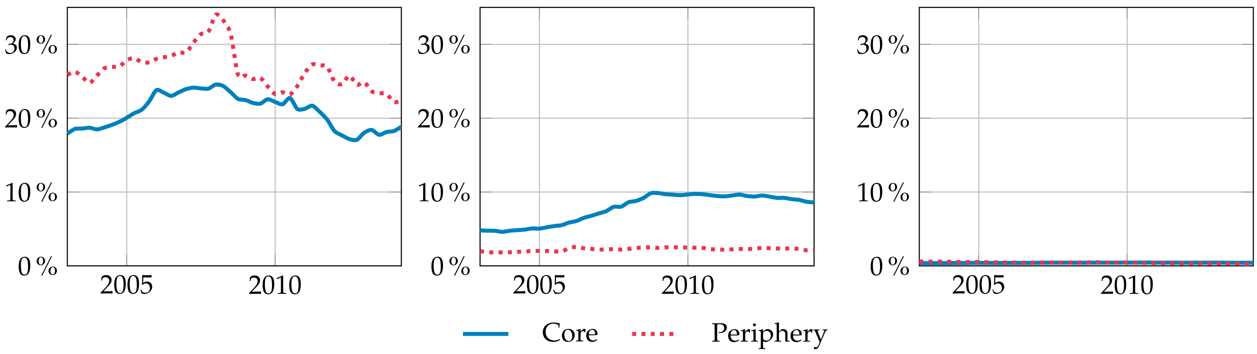
(a) Cross-border loans of MFIs residing in the euro area

(b) Total Amount of Banks' Foreign Claims in % of nominal GDP

FIGURE 4.1: Internationalization of credit markets in the Eurozone and abroad between 1999 and 2013 (*Sources ECB, BIS*)

the Eurozone. In Figure 4.2, we split the Eurozone in two groups: core countries and peripheral countries. In the first group we aggregate data for Germany and France, while in the second group, we aggregate data for Spain, Greece, Ireland, Italy and Portugal. We summarize the main stylized fact by contrasting interbank loans (in panel (a)), Corporate loans (in panel (b)) and loans to households (in panel (c)). Cross border loans are reported as the percentage of loans exported to the other economies either by core countries (plain lines) or peripheral countries (dotted lines). Thus, each curve represents the percentage points of loans exported by the relevant group of countries towards the rest of the Monetary Union.

The picture clearly shows the main contribution of interbank loans to cross border lending in the Eurozone, as they represent 25% on average over the sample period for peripheral countries and 20% for core countries. The financial crisis of 2008 had a clear depressing impact on cross-border lending from peripheral countries while it left cross-border lending from core countries almost unchanged. Peripheral countries cross-border lending to firms is low and remains constant over the sample period (averaging 2% of total loan creation) while it has clearly increased for core countries before the propagation



(a) Interbank Loans

(b) Corporate Loans

(c) Loans to Households

FIGURE 4.2: Share of Cross-Border Loans between EMU participants in the assets of Core and Peripheral Banks

of the financial crisis in the Eurozone (from 5% of total national loans in 2003 to 10% in 2008). The financial crisis has affected cross-border lending by stabilizing its level at around 10% over these last years for core countries, while having no noticeable effect for peripheral countries. Finally, cross-border lending to households is almost negligible over the sample period: it represents a constant value of 0.4% of total household loans for core countries and almost the same value on average (with a monotone downward trend) for peripheral countries.

2.2 A quick summary of the related literature

Recently a few authors have proposed DSGE models with cross-border lending features to assess the relevance of financial factors in the international transmission of shocks. Moreover, these models fall in one of the three following categories: international financial accelerators (Dedola & Lombardo (2012) and Ueda (2012)), Global banks (Kollmann et al. (2011) and Kalemli-Ozcan et al. (2013)) and international borrowing constraint (Faia & Iliopulos (2011) and Guerrieri et al. (2012)). However, none of these papers analyses the heterogeneity in cross-border lending flows combining corporate and interbank loans.

Concerning the first category of models of international credit cycles, Dedola & Lombardo (2012) suggest that cross-border spillovers result from holding foreign assets by domestic agents. In their model, entrepreneurs solve an endogenous portfolio choice problem composed by home and foreign assets. A variation of asset prices in one economy has side effects on the other economy, as investors sell or buy both domestic and foreign assets. Analytically, this model has to be solved using a second-order approximation to the policy function.[5] In the same vein, Ueda (2012) extends the financial accelerator in a two-country framework and imposes a credit constraint for both entrepreneurs and banks using a financial accelerator mechanism. Under banking globalization, the cost of capital in the economy depends on the capital to net wealth ratio of home and foreign entrepreneur and banks. The model of Ueda is close to Dedola and Lombardo, as entrepreneurs and banks maximize profits that combine an average of home and foreign funds calibrated in steady state.

Turning to the second category, both Kollmann et al. (2011) and Kalemli-Ozcan et al. (2013) consider a two-country environment with a global banking sector. When the capitalization of global banks declines, it reduces credit supply and depresses economic activity in both countries. In their setting financial frictions are reinforced by the fact that bank losses raise intermediation costs in both countries, triggering synchronized business fluctuations. However, these models consider an homogeneous banking system in the Eurozone while we introduce asymmetries in lending rate settings and financial shocks between the core and the periphery to account for financial heterogeneity in the Eurozone.

Faia & Iliopulos (2011) develop a small open economy DSGE model with durable and non durable goods sectors where households face a collateral constraint on the foreign level of debt. The model offers a reduced form of the banking system and concentrates on housing that is financed through foreign lending. We do not use this model for our purposes given the marginal flows of cross-border loans for house purchases encountered in Eurozone data as showed in Figure 4.2. Furthermore, as a small open country model, it can not be kept for our analysis that requires a two-country model. Finally, in the model developed by Guerrieri et al. (2012), banks grant loans to firms and invest in bonds issued by home and foreign government. The model is calibrated on the Euro area. In a two-country set-up, there are core and peripheral countries where large contractionary shocks trigger sovereign default. This model is well suited to analyze the diffusion of sovereign default risk in the Eurozone as shock to the value of peripheral bonds have side effects on the core economy. The model is also very rich in terms of financial frictions. However, the model is aimed at evaluating the diffusion of a sovereign debt crisis, a topic not covered in this chapter.

One of the novelty of our analysis is to provide a simple way to model cross-border lending activity to account for the previous stylized facts. To take our two-country model

[5]Bringing the model to the data is very challenging as if the estimated variance of the shocks are too big (which is mainly the case with financial data), the IRFs may diverge with a second order approximation. The solution we adopt in this chapter does not need a second order approximation contrary to their framework.

to the data easily, we assume that the banking system determines the loan interest rate while the quantity of loans that is contracted is determined by loan demand. Thus, in this chapter, rather than assuming that loans result of optimal portfolio choices from the supply side of the credit market, we suppose that the cross-border decisions arise from the demand side of credit market. International financial linkages are analogous to the external trade channels, assuming that a CES function aggregates domestic and international lending. This choice - that borrows from the New Open Economy Macroeconomics (NOEM) - remains quite simplistic but offers an interesting feature when going to the empirical estimation of the model and a simple reinterpretation of the financial accelerator from a banking perspective.

3 A Monetary Union with Cross-border Loans

We describe a two-country world. The two countries are equal in size and share a common currency. Each country $i \in \{h, f\}$ (where h is for home and f for foreign) is populated by consumers, labor unions, intermediate and final producers, entrepreneurs, capital suppliers and a banking system. Regarding the conduct of macroeconomic policy, we assume national fiscal authorities and a common central bank. As in Christiano et al. (2005) and Smets & Wouters (2003, 2007), we account for several sources of rigidities to enhance the empirical relevance of the model. The set of real rigidities encompasses consumption habits, investment adjustment costs, loan demand habits. Regarding nominal rigidities, we account for stickiness in final goods prices, wages and loan interest rates.

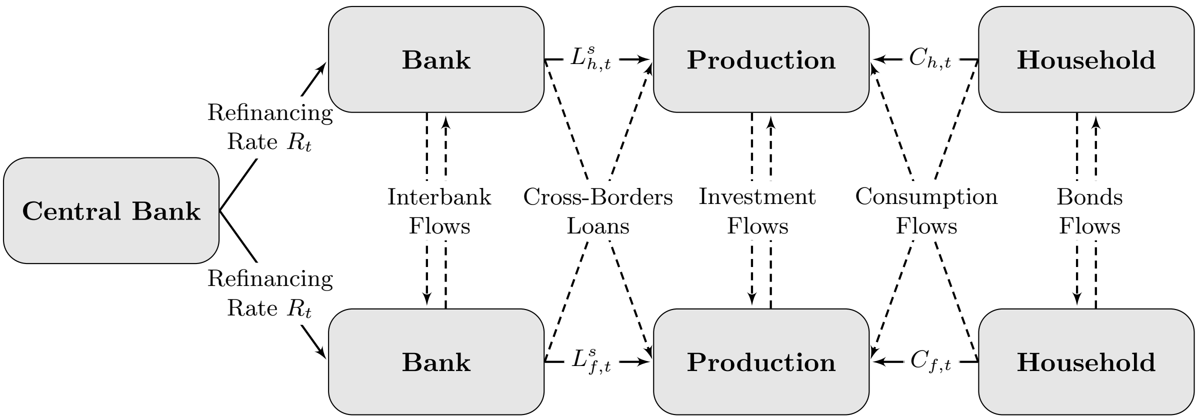


FIGURE 4.3: The model of a two-country monetary union with international bank loan flows

The general structure of the model is summarized in Figure 4.3. For expository purposes, this section describes the financial component of the model. We first outline the structure of the banking system that gives rise to cross-border interbank loan, then we describe the origin of cross-border corporate loans. The standard new Keynesian and RBC components of the model are presented afterward in Section 4.

3.1 An Heterogenous Banking System

In each country, the banking sector finances investment projects to home and foreign entrepreneurs by supplying one period loans. The banking system is heterogenous with regard to liquidity, and banks engage in interbank lending at the national and international levels. Thus, cross-border loans are made of corporate loans (between banks and entrepreneurs) and interbank loans.

To introduce an interbank market, we suppose that the banking system combines liquid and illiquid banks. Normalizing the total number of banks in each economy to 1, we assume that banks distributed over $[0, \lambda]$ are illiquid *(i.e.* credit constrained), while the remaining banks distributed over share $[\lambda, 1]$ are liquid and supply loans to entrepreneurs and to illiquid banks. We assume that a liquid bank is characterized by her direct accessibility to the ECB fundings. Conversely, an illiquid bank does not have access to the ECB fundings. This assumption is empirically motivated: in the Eurosystem, only a fraction of the 2500 banks participates regularly to the bidding process in main refinancing operations of the ECB while the others rely on interbank funding, as underlined by Gray et al. (2008). Extending this assumption in an international perspective, illiquid banks can borrow from both domestic and foreign liquid banks, which gives rise to cross-border interbank lending flows.

3.1.1 Illiquid Banks

The representative illiquid bank $b \in [0, \lambda]$ in country i operates under monopolistic competition to provide a quantity of loans $L^s_{i,t+1}(b)$ to entrepreneurs that is financed by interbank loans $IB_{i,t+1}(b)$ from the interbank market (with a one period maturity) at a rate $P^{IB}_{i,t}$. The balance sheet of the bank writes:

$$L^s_{i,t+1}(b) = IB^{\mathcal{H}}_{i,t+1}(b) + BK_{i,t+1}(b) + liab_{i,t}, \tag{4.1}$$

where $L^s_{i,t+1}(b)$ is the loan supply of borrowing banks, $IB^{\mathcal{H}}_{i,t+1}(b)$ is the interbank loans supplied by liquid banks subject to external habits, $BK_{i,t+1}(b)$ is the bank capital and $liab_{i,t}$ are other liabilities in the balance sheet of the bank that are not considered in the model[6]. We suppose that the demand for interbank funds are subject to external habits

[6]We suppose that they follow an exogenous $AR(1)$ shock process $\varepsilon^B_{i,t}$ such that, $liab_{i,t} = e^{\varepsilon^B_{i,t}}\overline{liab}_i$, this shock captures some aggregate movements in the capital constraint of banks.

at a degree h_i^{ib} where, $IB^{\mathcal{H}}_{i,t+1}(b) = IB^{d}_{i,t+1}(b) - h_i^{ib}\left(IB^{d}_{i,t+1} - \overline{IB^{d}_{i}}\right)$. These habits are deemed necessary to catch up the high autocorrelation observed in the supply of loans[7].

This bank engages in corporate loans. In this setting, we assume that there is no discrimination between borrowers, so that the representative and risk-neutral bank serves both domestic and foreign entrepreneurs without taking into account specificities regarding the national viability of projects. Bank default expectation regarding entrepreneurs' projects is defined as, $\eta_{i,t+1} \equiv \left(1-\alpha_i^L\right)\eta^E_{h,t+1} + \alpha_i^L \eta^E_{f,t+1}$, where $\eta^E_{i,t+1}$is the default rate in country $i \in \{h,f\}$ of entrepreneurs and $\left(1-\alpha_i^L\right)$ measures the home bias in corporate loan distribution. Thus, the marginal cost of one unit of corporate loan $MC^{ill}_{i,t}(b)$ provided by the illiquid bank is the solution of the expected profit $\mathbb{E}_t\Pi^B_{i,t+1}(b)$ optimization problem:

$$\max_{L^s_{i,t+1}(b)} \mathbb{E}_t \eta_{i,t+1} MC^{ill}_{i,t}(b) L^s_{i,t+1}(b) - P^{IB}_{i,t}\left(L^s_{i,t+1}(b) - BK_{i,t+1}(b) - liab_t(b)\right). \quad (4.2)$$

The marginal cost of one unit of loan, denoted $MC^{ill}_{i,t}(b)$, is the same across illiquid banks:

$$MC^{ill}_{i,t}(b) = MC^{ill}_{i,t} = \frac{P^{IB}_{i,t}}{\mathbb{E}_t\eta_{i,t+1}}, \quad (4.3)$$

so that each bank decides the size of the spread depending on the expected failure rate of its customers $\mathbb{E}_t\eta_{i,t+1}$.The bank has access to domestic and foreign interbank loans to meet its balance sheet. The total amount borrowed by the representative bank writes:

$$IB^d_{i,t+1}(b) = \left(\left(1-\alpha_i^{IB}\right)^{1/\xi} IB^d_{h,i,t+1}(b)^{(\xi-1)/\xi} + \left(\alpha_i^{IB}\right)^{1/\xi} IB^d_{f,i,t+1}(b)^{(\xi-1)/\xi}\right)^{\xi/(\xi-1)}, \quad (4.4)$$

where parameter ξ is the elasticity of substitution between domestic and foreign interbank funds, α_i^{IB} represents the percentage of cross-border interbank loan flows in the monetary union and $IB^d_{h,i,t+1}(b)$ (resp. $IB^d_{f,i,t+1}(b)$) the amount of domestic (resp. foreign) loans demanded by borrowing bank b in country i. The total cost incurred by illiquid banks to finance interbank loans, $P^{IB}_{i,t}$, is thus defined according to the CES aggregator:

$$P^{IB}_{i,t} = \left(\left(1-\alpha_i^{IB}\right)\left(R^{IB}_{h,t}\right)^{1-\xi} + \alpha_i^{IB}\left(R^{IB}_{f,t}\right)^{1-\xi}\right)^{1/(1-\xi)}, \quad (4.5)$$

where $R^{IB}_{h,t}$ (resp. $R^{IB}_{f,t}$) is the cost of loans obtained from home (resp. foreign) banks in country i. The decision to borrow from a particular bank is undertaken on the basis of

[7]In the fit exercise, DSGE models with banking are estimated on the outstanding amount of loans contracted in the economy. Since DSGE models only include one-period maturity loans, external habits are a tractable way to catch up the high persistence in the loan contracts without modifying the steady state. Guerrieri et al. (2012) develops a similar financial friction in the borrowing constraint of entrepreneurs.

relative interbank national interest rates:

$$IB^d_{h,i,t+1}(b) = \left(1-\alpha_i^{IB}\right)\left[\frac{R^{IB}_{h,t}}{P^{IB}_{i,t}}\right]^{-\xi} IB^d_{i,t+1}(b)\,,\text{ and } IB^d_{f,i,t+1}(b) = \alpha_i^{IB}\left[\frac{R^{IB}_{f,t}}{P^{IB}_{i,t}}\right]^{-\xi} IB^d_{i,t+1}(b)\,.$$

Here, cross-border lending is measured through the values undertaken by $IB^d_{h,f,t+1}(b)$, (*i.e.*, interbank loans contracted by liquid foreign banks from domestic overliquid banks) and symmetrically by $IB^d_{f,h,t+1}(b)$ (*i.e.*, interbank loans contracted by liquid domestic banks from foreign overliquid banks). Finally following Hirakata et al. (2009), the bank capital accumulation process of illiquid banks ($BK_{i,t+1}(b)$) is determined by:

$$BK_{i,t+1}(b) = \left(1-\tau^{BK}\right)\Pi^B_{i,t}(b)\,, \tag{4.6}$$

where τ^{BK} is a proportional tax on the profits of the bank.

3.1.2 Liquid Banks

The representative liquid bank $b \in [\lambda; 1]$ in country i operates under monopolistic competition to provide a quantity of loans $L^s_{i,t+1}(b)$ to entrepreneurs. It also provides a quantity of interbank loans $IB^s_{i,t+1}(b)$ to illiquid banks. We suppose that the intermediation process between liquid and illiquid banks is costly: we introduce a convex monitoring technology *à la* Cúrdia & Woodford (2010) and Dib (2010) with a functional form $AC^{IB}_{i,t+1}(b) = \frac{\chi_i^{IB}}{2}\left(IB^s_{i,t+1}(b) - \overline{IB}^s_i(b)\right)^2$ where parameter χ_i^{IB} is the level of financial frictions between liquid banks in country i and home and foreign illiquid banks[8]. Loans created by the liquid bank are financed by one-period maturity loans from the central bank ($L^{ECB}_{i,t+1}(b)$) at the refinancing interest rate R_t. Finally, the bank's balance sheet is defined by:

$$L^s_{i,t+1}(b) + IB^s_{i,t+1}(b) = L^{ECB}_{i,t+1}(b) + BK_{i,t+1}(b) + liab_t(b)\,.$$

According to the behavior of illiquid banks, we assume that there is no discrimination between borrowers. The marginal cost of one unit of loan $MC^{liq}_{i,t}(b)$ solves the profit ($\Pi^B_{i,t}(b)$) maximization problem:

$$\max_{L^s_{i,t+1}(b), IB_{i,t+1}(b)} \mathbb{E}_t \eta_{i,t+1} MC^{liq}_{i,t}(b)\, L^s_{i,t+1}(b) + R^{IB}_{i,t}(b)\, IB^s_{i,t+1}(b) - R_t L^{ECB}_{i,t+1}(b) - AC^{IB}_{i,t+1}(b)\,. \tag{4.7}$$

[8]Contrary to Cúrdia & Woodford (2010) but in the same vein of Dib (2010), the monitoring technology does not alter the steady state of the model to keep the estimation of χ_i^{IB} as simple as possible. Several papers refer to monitoring technology functions in the intermediation process of banks, see for example Goodfriend & McCallum (2007) or Casares & Poutineau (2011).

The marginal cost of one unit of loan is the same for all liquid banks:

$$MC_{i,t}^{liq}(b) = MC_{i,t}^{liq} = \frac{R_t}{\mathbb{E}_t \eta_{i,t+1}}. \tag{4.8}$$

Similarly to the illiquid bank, bank capital evolves according to Equation 4.6[9].

Loan interest rates: There are two interest rates to be determined: the interest rate on the interbank market and the interest rate on corporate loans. First, on a perfectly competitive market, the interbank rate in country i is determined from the problem 4.7:

$$R_{i,t}^{IB}(b) = \chi_i^{IB}\left(IB_{i,t+1}(b) - \overline{IB}_i^s(b)\right) + R_t, \tag{4.9}$$

where, χ_i^{IB} is a cost parameter, $IB_{i,t+1}^s(b)$ is the amount of interbank loans contracted in period t with a one period maturity and $\overline{IB}_i^s(b)$ is the steady state value of interbank loans.

Second, the interest rate charged by banks of country i on corporate loans accounts for the liquidity of the national banking system. Anticipating over symmetric issues at the equilibrium to improve the tractability of the model, we assume that all banks belonging to a national banking system share the same marginal cost of production, reflecting the average liquidity degree of national banks. Thus, aggregating over each group of banks, we get, $\int_0^\lambda MC_{i,t}^{ill}(b)\mathrm{d}b = MC_{i,t}^{L,ill}$, and $\int_\lambda^1 MC_{i,t}^{liq}(b)\mathrm{d}b = MC_{i,t}^{liq}$. Aggregate marginal cost $MC_{i,t}^L$ combines outputs from liquid and illiquid banks of country i according to[10]:

$$MC_{i,t}^L = \left(MC_{i,t}^{ill}\right)^\lambda \left(MC_{i,t}^{liq}\right)^{(1-\lambda)} = \frac{\left(P_{i,t}^{IB}\right)^\lambda (R_t)^{(1-\lambda)}}{\mathbb{E}_t \eta_{i,t+1}}. \tag{4.10}$$

Thus, the representative bank $b \in [0;1]$ of country i operates under monopolistic competition to provide a quantity of loans $L_{i,t+1}^s(b)$ incurring a marginal cost $MC_{i,t}^L$. The marginal cost is the same for all banks b and depends on the expected failure rate of borrowers' projects and the central bank refinancing rate. Equation 4.10 taken in logs becomes:

$$\widehat{mc}_{i,t}^L = \frac{1}{\left(1-\bar{N}/\bar{K}\right)}\left[\left(1-\alpha_i^L\right)(1-\varkappa_i)\,\widehat{lev}_{i,t} + \alpha_i^L(1-\varkappa_j)\,\widehat{lev}_{j,t}\right] + (1-\lambda)\,\hat{r}_t + \lambda \hat{p}_{i,t}^{IB},$$

$\forall i \neq j \in \{h, f\}$, where, $\widehat{lev}_{i,t}$ is the leverage ratio of entrepreneurs and $\bar{N}/\bar{K}$ is the steady state net worth to capital ratio. Under Calvo pricing with partial indexation, banks set the interest rate on loans contracted by entrepreneurs on a staggered basis as

[9] The accumulation of bank capital is necessary to close the model but it is not binding for liquid banks as they are not credit constrained.

[10] We borrow this aggregation procedure from the solution introduced by Gerali et al. (2010), to aggregate borrowing and saving households labor supply.

in Darracq-Pariès et al. (2011). A fraction θ_i^L of banks is not allowed to optimally set the credit rate[11] and index it by ξ_i^L percent of the past credit rate growth, $R_{i,t}^L(b) = \left(R_{i,t-1}^L/R_{i,t-2}^L\right)^{\xi_i^L} R_{i,t-1}^L(b)$. Assuming that it is able to modify its loan interest rate with a constant probability $1-\theta_i^L$, it chooses $R_{i,t}^{L*}(b)$ to maximize its expected sum of profits:

$$\max_{\left\{R_{i,t}^{L*}(b)\right\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^L \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \eta_{i,t+1+\tau} \left[\left(1-\tau^L\right) R_{i,t}^{L*}(b)\, \Xi_{i,t,\tau}^L - MC_{i,t+\tau}^L\right] L_{i,t+1+\tau}(b) \right\},$$

subject to, $L_{i,t+1+\tau}(b) = \left(\Xi_{i,t,\tau}^L R_{i,t}^{L*}(b) / R_{i,t+\tau}^L\right)^{-\mu_{i,t+\tau}^L/\left(\mu_{i,t+\tau}^L-1\right)} L_{i,t+1+\tau}$, $\forall \tau > 0$, where $\Xi_{i,t,\tau}^L = \prod_{k=1}^{\tau}\left(R_{i,t+k-1}^L/R_{i,t+k-2}^L\right)^{\xi_i^L}$ is the sum of past credit rate growth and $L_{i,t}(b)$ denotes the quantity of differentiated banking loans b that is used by the retail banks[12]. The time-varying markup is defined by, $\mu_{i,t}^L = \mu_L + \varepsilon_{i,t}^L$, so that an increase in $\varepsilon_{i,t}^L$ can be interpreted as a cost-push shock to the credit rate equation[13]. As Benigno & Woodford (2005), we introduce a proportional tax τ^L on profits that restores the first-best allocation in the steady state. Allowing for a partial indexation of credit interest rates on their previous levels (where $\xi_i^L \in [0;1]$ is the level of indexation that catches some imperfect interest rate pass-though with θ_i^L), and imposing symmetry, the log equation of the real loan interest rate in country i is set according to:

$$\hat{r}_{i,t}^L = \frac{1}{1+\beta\left(1+\xi_i^L\right)} \begin{pmatrix} \left(1+\xi_i^L(1+\beta)\right)\hat{r}_{i,t-1}^L - \xi_i^L \hat{r}_{i,t-2}^L + \beta \mathbb{E}_t \hat{r}_{i,t+1}^L \\ +\beta\theta_i^L \mathbb{E}_t \hat{\pi}_{i,t+2}^c - \left(1+\beta\theta_i^L\right)\mathbb{E}_t\hat{\pi}_{i,t+1}^c + \hat{\pi}_{i,t}^c \\ +\frac{\left(1-\theta_i^L\right)\left(1-\theta_i^L\beta\right)}{\theta_i^b}\left[\widehat{mc}_{i,t}^L - \hat{r}_{i,t}^L\right] \end{pmatrix} + \varepsilon_{i,t}^L. \quad (4.11)$$

Solving this equation forward, one can see that past, current and expected future marginal cost of loans are driving today's loan interest rate. With fully flexible rates ($\theta_i^L = 0$), the loan interest rate $\hat{r}_{i,t}^L$ is a function of the interest rate and the expected profitability share of investment projects, that is $\hat{r}_{i,t}^L = \widehat{mc}_{i,t}^L + \varepsilon_{i,t}^L = \hat{r}_t - E_t\widehat{\eta}_{i,t+1} + \varepsilon_{i,t}^L$. Since credit risk is measured by the level of firm leverage in the economy, credit rates reflect both past and future risk in the economy caught up by parameters ξ_i^L and θ_i^L.

[11] This parameter, once estimated in the next section, will serve as a measure to measure the flexibility of national banking systems in the transmission of interest rate decisions.

[12] Retail banks are perfectly competitive loan packers, they buy the differentiated loans and aggregate them through a CES technology into one loan and sell them to entrepreneurs.

[13] Differentiated loans are imperfect substitutes, with elasticitity of substitution denoted by $\frac{\mu_L}{(\mu_L-1)}$.

3.2 Entrepreneurs and Corporate loans

Cross-border corporate loans occur between entrepreneurs and banks. In each economy, the representative entrepreneur $e \in [0,1]$ finances the capital renting of intermediate firms. In period t, entrepreneur e conducts a great number of heterogenous projects with total value $Q_{i,t}K_{i,t+1}(e)$, (where $Q_{i,t}$ is the price of capital and $K_{i,t+1}(e)$ is the amount of capital financed). These projects are financed by his net wealth and by loans from the banking system $(L^d_{i,t+1}(e))$. The balance sheet of the representative entrepreneur writes:

$$Q_{i,t}K_{i,t+1}(e) - N_{i,t+1}(e) = L^{\mathcal{H}}_{i,t+1}(e). \tag{4.12}$$

where $L^{\mathcal{H}}_{i,t+1}(e) = L^d_{i,t+1}(e) - h^L_i\left(L^d_{i,t} - L^d_i\right)$ denotes external demand habits for loans[14]. The entrepreneur has access to domestic and foreign banks to meet its balance sheet. The total amount borrowed by the representative entrepreneur writes:

$$L^d_{i,t+1}(e) = \left(\left(1-\alpha^L_i\right)^{1/\nu} L^d_{h,i,t+1}(e)^{(\nu-1)/\nu} + \left(\alpha^L_i\right)^{1/\nu} L^d_{f,i,t+1}(e)^{(\nu-1)/\nu}\right)^{\nu/(\nu-1)}, \tag{4.13}$$

where parameter ν is the elasticity of substitution between domestic and foreign loans, α^L_i represents the percentage of cross-border loan flows in the monetary union and $L^d_{h,i,t+1}(e)$ (resp. $L^d_{f,i,t+1}(e)$) the amount of domestic (resp. foreign) loans demanded by entrepreneur e in country i. The total cost of loans, $P^L_{i,t}$, is thus defined according to:

$$P^L_{i,t}(e) = \left(\left(1-\alpha^L_i\right) R^L_{h,t}(e)^{1-\nu} + \alpha^L_i R^L_{f,t}(e)^{1-\nu}\right)^{1/(1-\nu)}, \tag{4.14}$$

where $R^L_{h,t}(e)$ (resp. $R^L_{f,t}(e)$) is the cost of loans obtained from home (resp. foreign) banks by entrepreneur e in country i. The decision to borrow from a particular bank is undertaken on the basis of relative national interest rates:

$$L^d_{h,i,t+1}(e) = \left(1-\alpha^L_i\right)\left[\frac{R^L_{h,t}(e)}{P^L_{i,t}(e)}\right]^{-\nu} L^d_{i,t+1}(e), \text{ and, } L^d_{f,i,t+1}(e) = \alpha^L_i \left[\frac{R^L_{f,t}(e)}{P^L_{i,t}(e)}\right]^{-\nu} L^d_{i,t+1}(e).$$

The investment projects undertaken by the entrepreneur are risky and differ with respect to their individual returns. To model individual riskiness, we assume that each project has an individual return equal to $\omega R^k_{i,t}$, *i.e.* that the aggregate return of investment projects in the economy $R^k_{i,t}$ is multiplied by a random value ω (drawn from a Pareto

[14] These lending demand habits are deemed necessary to replicate the dynamic of loans. In the estimation exercise, we use the total stock of loans, they are of different maturities implying a strong autocorrelation. Simply by introducing loan demand habits, taking into account the high autocorrelation of loans becomes tractable easily and does not change the steady state of the model.

distribution[15]). Defining the value for a profitable project by $\bar{\omega}_{i,t}(e) = E\left(\omega | \omega \geq \omega_{i,t}^{C}(e)\right)$ (where $\omega_{i,t}^{C}(e)$ is the critical value of ω that distinguishes profitable and non profitable projects), the profit function of entrepreneur e after aggregating all projects writes:

$$\Pi_{i,t+1}^{E}(e) = \begin{cases} \bar{\omega}_{i,t+1} R_{i,t+1}^{k} Q_{i,t} K_{i,t+1}(e) - P_{i,t}^{L}(e) L_{i,t+1}^{\mathcal{H}}(e) \text{ with probability } \eta_{i,t+1}^{E}, \\ 0 \text{ with probability } 1 - \eta_{i,t+1}^{E}, \end{cases} \tag{4.15}$$

where $\eta_{i,t+1}^{E}$ is the time-varying expected share of gainful projects. Since entrepreneurs cannot screen the value of $\bar{\omega}_{i,t+1}(e)$ *ex ante*, $\omega_{i,t}^{C}(e)$ cannot be a control variable of the financial contract between borrowers and lenders contrary to Bernanke et al. (1999). To introduce a financial accelerator mechanism, we borrow a concept of De Grauwe (2010) applied in a different context, by assuming that entrepreneurs' forecasts regarding the aggregate profitability of a given project $\bar{\omega}_{i,t}(e)$ are optimistic (*i.e.*, biased upwards)[16]. The perceived *ex ante* value of profitable projects is defined by the isoleastic function:

$$g\left(\bar{\omega}_{i,t+1}, \varepsilon_{i,t}^{Q}\right) = \gamma_i \left(\bar{\omega}_{i,t+1}\right)^{\frac{\varkappa_i}{(\varkappa_i - 1)}} \left(e^{\varepsilon_{i,t}^{Q}}\right)^{\frac{1}{(\varkappa_i - 1)}},$$

where $\varepsilon_{i,t}^{Q}$ is an $AR(1)$ process[17], $\varkappa_i$ is the elasticity of the external finance premium[18] and γ_i is a scale parameter[19]. In this expression, the exogenous shock is affected by exponent $1/(\varkappa_i - 1)$ to normalize to unity the impact of the financial shock $\varepsilon_{i,t}^{Q}$ in the log deviation form of the model. Thus, *ex-ante* the entrepreneur chooses a capital value of $K_{i,t+1}(e)$ that maximizes its expected profit defined as:

$$\max_{\{K_{i,t+1}(e)\}} \mathbb{E}_t \left\{ \eta_{i,t+1}^{E} \left[g\left(\bar{\omega}_{i,t+1}, \varepsilon_{i,t}^{Q}\right) R_{i,t+1}^{k} Q_{i,t} K_{i,t+1}(e) - P_{i,t}^{L}(e) L_{i,t+1}^{\mathcal{H}}(e) \right] \right\}. \tag{4.16}$$

[15]With respect to the standard framework standardly used in the literature (Bernanke et al., 1999), we assume that the heterogeneity in the return of investment project undertaken by firms is modeled using a Pareto distribution. This device commonly used in other branches of the economic literature provides a series of interesting features in the analysis and allows an easier estimation of the financial amplification effect. See subsubsection 1.5.2 (page 185) in appendices for further details about the computation of ω.

[16]Assuming optimistic firms is motivated empirally, Bachmann & Elstner (2013) find evidence of such expectations for German firms using microdata. The optimistic expectations hypothesis of the private sector is very close to the utility functions introduced by Goodhart et al. (2005) for bankers. In our setting, the financial accelerator does not result from a moral hazard problem but rather from a bias in the expectations of the private sector.

[17]This shock affects the expected profitability of financial projects by rising in exogeneously the risk premium implying an increase in the cost of capital and hence a reduction in investment as underlined by Gilchrist, Sim, & Zakrajsek (2009) for the US economy.

[18]The elasticity of the external finance premium expresses the degree of bias in estimating the expected rentability of entrepreneurs' projects such that if $\bar{\omega} > 1$ and $\varkappa_i > 0$ then $g(\bar{\omega}) > \bar{\omega}$. Expressed *à la* De Grauwe (2010), $\mathbb{E}_t^{opt} \bar{\omega}_{i,t+1} = \mathbb{E}_t \gamma_i \left(\bar{\omega}_{i,t+1}\right)^{\varkappa_i/(\varkappa_i - 1)}$ where $\mathbb{E}_t^{opt}$ is the expectation operator of optimistic entrepreneurs.

[19]This parameter is needed to make the steady state independent of $\varkappa_i$,such that $\gamma_i = \bar{\omega}^{1/(1-\varkappa_i)}$.

Using the characteristics of the Pareto distribution, the expected spread required by representative entrepreneur e to undertake the decision to finance firms' investment is:

$$S_{i,t}\left(e\right)=\frac{\mathbb{E}_{t}R_{i,t+1}^{k}}{P_{i,t}^{L}\left(e\right)}=\gamma_{i}^{\varkappa_{i}-1}\left[\frac{\kappa}{\kappa-1}\left(1-\frac{N_{i,t+1}\left(e\right)}{Q_{i,t}K_{i,t+1}\left(e\right)}\right)\right]^{\varkappa_{i}}e^{\varepsilon_{i,t}^{Q}}. \tag{4.17}$$

The size of the accelerator is determined by the elasticity of the external finance premium $\varkappa_i$. For $\varkappa_i > 0$, the external finance premium is a positive function of the leverage ratio, $Q_{i,t}K_{i,t+1}\left(e\right)/N_{i,t+1}\left(e\right)$, so that an increase in net wealth induces a reduction of the external finance premium. This phenomenon disappears if $\varkappa_i = 0$. Concerning the exogenous movements of the external finance premium, a positive realization of $\varepsilon_{i,t}^{Q}$ means that entrepreneurs require a higher expected profitability of capital $E_tR_{i,t+1}^{k}$ to finance investment for a given level of lending conditions $P_{i,t}^{L}$. Furthermore, a shock that hits the entrepreneur net wealth $N_{i,t+1}\left(e\right)$ will also affect the rentability of the physical capital in the economy. As the rentability of capital is a cost for the intermediate sector, a variation in the net wealth will have aggregate consequences on goods supply through the channel of the capital market as underlined by Gilchrist, Sim, & Zakrajsek (2009). The amount of capital of non-profitable entrepreneurs' investment projects is consumed in terms of home final goods $P_{i,t}\left(1-\eta_{i,t}^{E}\right)\underline{\omega}_{i,t}\left(e\right)R_{i,t}^{k}Q_{i,t-1}K_{i,t}\left(e\right)$. Thus the net wealth of the entrepreneur in the next period is equal to:

$$N_{i,t+1}\left(e\right)=\left(1-\tau^{E}\right)\frac{\Pi_{i,t}^{E}\left(e\right)}{e^{\varepsilon_{i,t}^{N}}}, \tag{4.18}$$

where $\varepsilon_{i,t}^{N}$ is an exogenous process of net wealth destruction and τ^{E} is a proportional tax on the profits of the entrepreneur.

4 The Rest of the Model

This section describes the real component of the model: Households, labour unions, firms, capital suppliers, the authorities and the general equilibrium conditions.

4.1 Households

In each economy there is a continuum of identical households who consume, save and work in intermediate firms. The total number of households is normalized to 1. The representative household $j\in[0,1]$ maximizes the welfare index:

$$\max_{\{C_{i,t}(j),H_{i,t}(j),B_{i,t+1}(j)\}}\mathbb{E}_{t}\sum_{\tau=0}^{\infty}\beta^{\tau}e^{\varepsilon_{i,t+\tau}^{U}}\left[\frac{\left(C_{i,t+\tau}\left(j\right)-h_{i}^{C}C_{i,t-1+\tau}\right)^{1-\sigma_{i}^{C}}}{1-\sigma_{i}^{C}}-\chi_{i}\frac{H_{i,t+\tau}^{1+\sigma_{i}^{L}}\left(j\right)}{1+\sigma_{i}^{L}}\right], \tag{4.19}$$

subject to:

$$\frac{W_{i,t}^{h}}{P_{i,t}^{C}}H_{i,t}(j)+R_{t-1}\frac{B_{i,t}(j)}{P_{i,t}^{C}}+\frac{\Pi_{i,t}(j)}{P_{i,t}^{C}}=C_{i,t}(j)+\frac{B_{i,t+1}(j)}{P_{i,t}^{C}}+\frac{T_{i,t}(j)}{P_{i,t}^{C}}+\frac{P_{i,t}}{P_{i,t}^{C}}AC_{i,t}^{B}(j)\,. \tag{4.20}$$

Here, $C_{i,t}(j)$ is the consumption index, $h_i^C \in [0,1]$ is a parameter that accounts for consumption habits, $H_{i,t}(j)$ is labor effort, $\varepsilon_{i,t}^U$ is an exogenous $AR(1)$ shock to household preferences. The income of the representative household is made of labor income (with nominal wage, $W_{i,t}^h$), interest payments for bond holdings, (where $B_{i,t}(j)$ stands for the bonds subscribed in period $t-1$ and R_{t-1} is the gross nominal rate of interest between period $t-1$ an period t), and earnings $\Pi_{i,t}(j)$ from shareholdings[20]. The representative household spends this income on consumption, bond subscription and tax payments (for a nominal amount of $T_{i,t}(j)$). Finally, he has to pay quadratic adjustment costs to buy new bonds (Schmitt-Grohé & Uribe, 2003), according to the function, $AC_{i,t}^B(j)=\frac{\chi^B}{2}\left(B_{i,t+1}(j)-\bar{B}_i(j)\right)^2$, where $\bar{B}_i(j)$ is the steady state level of bonds. The first order conditions that solve this problem can be summarized with an Euler bond condition:

$$\frac{\beta R_t}{1+P_{i,t}\chi^B\left(B_{i,t+1}(j)-\bar{B}_i(j)\right)}=\mathbb{E}_t\left\{\frac{e^{\varepsilon_{i,t}^U}}{e^{\varepsilon_{i,t+1}^U}}\frac{P_{i,t+1}^C}{P_{i,t}^C}\left(\frac{\left(C_{i,t+1}(j)-h_i^C C_{i,t}\right)}{\left(C_{i,t}(j)-h_i^C C_{i,t-1}\right)}\right)^{\sigma_i^C}\right\}, \tag{4.21}$$

and a labor supply function:

$$\frac{W_{i,t}^h}{P_{i,t}^C}=\chi_i H_{i,t}(j)^{\sigma_i^L}\left(C_{i,t}(j)-h_i^C C_{i,t-1}\right)^{\sigma_i^C}\,. \tag{4.22}$$

The consumption basket of the representative household and the consumption price index of country i are, $C_{i,t}(j)=\left(\left(1-\alpha_i^C\right)^{1/\mu}C_{h,i,t}(j)^{(\mu-1)/\mu}+\left(\alpha_i^C\right)^{1/\mu}C_{f,i,t}(j)^{(\mu-1)/\mu}\right)^{\mu/(\mu-1)}$ and $P_{i,t}^C=\left(\left(1-\alpha_i^C\right)P_{h,t}^{1-\mu}+\alpha_i^C P_{f,t}^{1-\mu}\right)^{1/(1-\mu)}$ where μ is the elasticity of substitution between the consumption of home $(C_{h,i,t}(j))$ and foreign $(C_{f,i,t}(j))$ goods and α_i^C is the degree of openness of the economy. In this model, we assume home bias in consumption, so that $\alpha_i^C<\frac{1}{2}$.

4.2 Labor Unions

Households provide differentiated labor types, sold by labor unions to perfectly competitive labor packers who assemble them in a CES aggregator and sell the homogenous labor to intermediate firms. Each representative union is related to an household $j\in[0,1]$. Assuming that the trade union is able to modify its wage with a probability $1-\theta_i^W$, it

[20]The nominal amounts of dividends received from final good producers $\Pi_{i,t}^Y(j)$ and labor unions $\Pi_{i,t}^W(j)$ writes $\Pi_{i,t}(j)=\Pi_{i,t}^Y(j)+\Pi_{i,t}^W(j)$.

chooses the optimal wage $W_{i,t}^{*}(j)$ to maximize its expected sum of profits:

$$\max_{\{W_{i,t}^{*}(j)\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^W \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}} \left[\left(1-\tau^W\right) \frac{W_{i,t}^{*}(j)}{P_{i,t+\tau}^{C}} \prod_{k=1}^{\tau} \left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^W} - \frac{W_{i,t+\tau}^{h}(j)}{P_{i,t+\tau}^{C}} \right] H_{i,t+\tau}(j) \right\},$$

subject to the downgrade sloping demand constraint from labor packers, $H_{i,t+\tau}(j) = \left(W_{i,t}^{*}(j) / W_{i,t+\tau} \prod_{k=1}^{\tau} \left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^W} \right)^{-\mu_{i,t+\tau}^{W}/\left(\mu_{i,t+\tau}^{W}-1\right)} H_{i,t+\tau}$, $\forall \tau > 0$, where $H_{i,t}(j)$ denotes the quantity of differentiated labor types j that is used in the labor packer production with time-varying substitutability $\mu_{i,t}^{W} / \left(\mu_{i,t}^{W}-1\right)$ between different labor varieties. The first order condition results in the following equation for the re-optimized real wage:

$$\frac{W_{i,t}^{*}(j)}{P_{i,t}^{C}} = \frac{\mu_{i,t+\tau}^{W}}{\left(1-\tau^W\right)} \frac{\mathbb{E}_t \sum_{\tau=0}^{\infty} \frac{\left(\theta_i^W \beta\right)^{\tau}}{\left(\mu_{i,t+\tau}^{W}-1\right)} \frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}} \frac{W_{i,t+\tau}^{h}(j)}{P_{i,t+\tau}^{C}} H_{i,t+\tau}(j)}{\mathbb{E}_t \sum_{\tau=0}^{\infty} \frac{\left(\theta_i^W \beta\right)^{\tau}}{\left(\mu_{i,t+\tau}^{W}-1\right)} \frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}} \prod_{k=1}^{\tau} \frac{\left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^w}}{\pi_{i,t+k}^{C}} H_{i,t+\tau}(j)} \tag{4.23}$$

The markup of the aggregate wage over the wage received by the households is taxed by national governments (at rate τ_i^W that cancels the markup in steady state (Benigno & Woodford, 2005)).

4.3 Firms

This sector is populated by two groups of agents: intermediate firms and final firms. Intermediate firms produce differentiated goods i, choose labor and capital inputs, and set prices according to the Calvo model. Final goods producers act as a consumption bundler by combining national intermediate goods to produce the homogenous final good[21].

Concerning the representative intermediate firm $i \in [0,1]$, it has the following technology, $Y_{i,t}(i) = e^{\varepsilon_{i,t}^{A}} K_{i,t}^{u}(i)^{\alpha} H_{i,t}^{d}(i)^{1-\alpha}$, where $Y_{i,t}(i)$ is the production function of the intermediate good that combines (an effective quantity of) capital $K_{i,t}^{u}(i)$, labor $H_{i,t}^{d}(i)$ and technology $e^{\varepsilon_{i,t}^{A}}$ (an $AR(1)$ productivity shock)[22]. Intermediate goods producers solve a two-stage problem. In the first stage, taking the input prices $W_{i,t}$ and $Z_{i,t}$ as given, firms rent inputs $H_{i,t}^{d}(i)$ and $K_{i,t}^{u}(i)$ in a perfectly competitive factor markets in order to minimize costs subject to the production constraint. The first order condition

[21] Final good producers are perfectly competitive and maximize profits, $P_{i,t} Y_{i,t}^{d} - \int_0^1 P_{i,t}(i) Y_{i,t}(i) \mathrm{d}i$, subject to the production function $Y_{i,t}^{d} = \left(\int_0^1 Y_{i,t}(i)^{(\epsilon_p-1)/\epsilon_p} \mathrm{d}i\right)^{\epsilon_p/(\epsilon_p-1)}$. We find the intermediate demand functions associated with this problem are, $Y_{i,t}(i) = \left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_p} Y_{i,t}^{d}$, $\forall i$. where $Y_{i,t}^{d}$ is the aggregate demand.

[22] As in Smets & Wouters (2003, 2007), we assume that capital requires one period to be settled so that, $K_{i,t}^{u}(i) = u_{i,t} K_{i,t-1}(i)$ given a (variable) level of capital utilization of capital $u_{i,t}$, and a quantity of capital $K_{i,t}(i)$ provided to the intermediate firm in the previous period. Both the level of $u_{i,t}$ and the quantity $K_{i,t}(i)$ are determined below by capital suppliers.

leads to the marginal cost expression:

$$MC_{i,t}(i) = MC_{i,t} = \frac{1}{e^{\varepsilon^A_{i,t}}} \left(\frac{Z_{i,t}}{\alpha}\right)^{\alpha} \left(\frac{W_{i,t}}{(1-\alpha)}\right)^{(1-\alpha)}. \tag{4.24}$$

From the cost minimization problem, inputs also satisfy, $\alpha H^d_{i,t}(i) W_{i,t} = Z_{i,t} K^u_{i,t}(i)(1-\alpha)$.

In the second-stage, firm i sets the price according to a Calvo mechanism. Each period, firm i is not allowed to reoptimize its price with probability θ^P_i but price increases of $\xi^P_i \in [0;1]$ at last period's rate of price inflation, $P_{i,t}(i) = \pi^{\xi^P_i}_{i,t-1} P_{i,t-1}(i)$. The firm allowed to modify its selling price with a probability $1-\theta^P_i$ chooses $\left\{P^*_{i,t}(i)\right\}$ to maximize its expected sum of profits:

$$\max_{\left\{P^*_{i,t}(i)\right\}} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} \left(\theta^P_i \beta\right)^{\tau} \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[\left(1-\tau^Y\right) P^*_{i,t}(i) \prod_{k=1}^{\tau} \pi^{\xi^P_i}_{i,t+k-1} - MC_{i,t+k} \right] Y_{i,t+\tau}(i) \right\},$$

under the demand constraint, $Y_{i,t+\tau}(i) = \left(\prod_{k=1}^{\tau} \pi^{\xi^P_i}_{i,t+k-1} P^*_{i,t}(i) / P_{i,t+\tau}\right)^{-\epsilon_P} Y^d_{i,t+\tau}$, $\forall$ $\tau > 0$, where $Y^d_{i,t}$ represents the quantity of the goods produced in country i, τ^Y is a proportional tax income on final goods producers' profits which removes the steady state price distortion caused by monopolistic competition (Benigno & Woodford, 2005), $\lambda^c_{i,t}$ is the household marginal utility of consumption. The first order condition that defines the price of the representative firm i is:

$$P^*_{i,t}(i) = \frac{\epsilon_P}{(\epsilon_P - 1)\left(1-\tau^Y\right)} \frac{\mathbb{E}_t \left\{ \sum\limits_{\tau=0}^{\infty} \left(\theta^P_i \beta\right)^{\tau} \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} MC_{i,t+k} Y_{i,t+\tau}(i) \right\}}{\mathbb{E}_t \left\{ \sum\limits_{\tau=0}^{\infty} \left(\theta^P_i \beta\right)^{\tau} \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \prod\limits_{k=1}^{\tau} \pi^{\xi^P_i}_{i,t+k-1} Y_{i,t+\tau}(i) \right\}}. \tag{4.25}$$

4.4 Capital Suppliers

Capital suppliers are homogeneous and distributed over a continuum normalized to one. The representative capital supplier $k \in [0;1]$ acts competitively to supply a quantity $K_{i,t+1}(k)$ of capital. Investment is costly, *i.e.* the capital supplier pays an adjustment cost $AC^I_{i,t}(k)$ on investment, such that $AC^I_{i,t}(k) = \frac{\chi^I_i}{2}\left(I_{i,t}(k)/I_{i,t-1}(k) - 1\right)^2$. The capital stock of the representative capital supplier thus evolves according to, $K_{i,t+1}(k) = \left(1 - AC^I_{i,t}(k)\right) I_{i,t}(k) + (1-\delta) K_{i,t}(k)$. The capital supplier produces the new capital stock $Q_{i,t} K_{i,t+1}(k)$ by buying the depreciated capital $(1-\delta) K_{i,t}(k)$ and investment goods $I_{i,t}(k)$, where $I_{i,t}(k) = \left(\left(1-\alpha^I_i\right)^{1/\mu} I_{h,i,t}(k)^{(\mu-1)/\mu} + \left(\alpha^I_i\right)^{1/\mu} I_{f,i,t}(k)^{(\mu-1)/\mu}\right)^{\mu/(\mu-1)}$. In this expression, parameter μ is the elasticity of substitution between domestic and foreign goods in investment and α^I_i measures the degree of investment diversification in the monetary union between home and foreign countries. We assume a national bias in investment choices so that, $\alpha_i^I < 0.5$. The price index of investment is, $P_{i,t}^I = \left(\left(1-\alpha_i^I\right)(P_{h,t})^{1-\mu} + \alpha_i^I (P_{f,t})^{1-\mu}\right)^{1/(1-\mu)}$. The representative capital supplier chooses $I_{i,t}(k)$ to maximize profits:

$$\max_{\{I_{i,t}(k)\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \beta^{\tau} \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[Q_{i,t}\left(1 - AC_{i,t}^I(k)\right) - P_{i,t}^I \right] I_{i,t}(k) \right\}, \tag{4.26}$$

where $\beta^{\tau}\frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c}$ is the household stochastic discount factor. The price of capital renting thus solves:

$$Q_{i,t} = P_{i,t}^I + Q_{i,t}\frac{\partial\left(I_{i,t}(k)\, AC_{i,t}^I(k)\right)}{\partial I_{i,t}(k)} + \beta\mathbb{E}_t \frac{\lambda_{i,t+1}^c}{\lambda_{i,t}^c} Q_{i,t+1} \frac{\partial\left(I_{i,t+1}(k)\, AC_{i,t+1}^I(k)\right)}{\partial I_{i,t}(k)}. \tag{4.27}$$

As in Smets & Wouters (2003, 2007), capital requires one period to be settled so that, $K_{i,t}^u = u_{i,t}K_{i,t-1}$ given a level of capital utilization of capital $u_{i,t}$. Thus, the return from holding one unit of capital from t to $t+1$ is determined by:

$$\frac{\mathbb{E}_t R_{i,t+1}^k}{1 + P_{i,t}\chi^B \left(B_{i,t+1}(j) - \bar{B}_i(j)\right)} = \mathbb{E}_t \left[\frac{Z_{i,t+1}u_{i,t+1} - P_{i,t+1}\Phi\left(u_{i,t+1}\right) + (1-\delta)\, Q_{i,t+1}}{Q_{i,t}} \right] \tag{4.28}$$

where $\Phi\left(u_{i,t+1}\right)$ is the capital utilization cost function. Thus, the optimal capital utilization determines the relationship between capital utilization and the marginal production of capital is defined in logs by, $\frac{\psi_i}{1-\psi_i}\hat{u}_{i,t} = \hat{z}_{i,t}$, where $\psi_i \in [0,1]$ is the elasticity of utilization costs with respect to capital inputs[23].

4.5 Authorities

National governments finance public spending by charging proportional taxes on profits arising from imperfect competition to compensate price distortions in the steady state and from entrepreneurs net wealth accumulation. Governments also receive a total value of taxes from households. The total amount of public spending, $P_{i,t}G_{i,t}$, is entirely home biased in the i^{th} economy[24] and evolves according to an AR(1) exogenous shock process

[23] When households do not take capital supply decisions, the optimal capital utilization is determined by solving, $\max_{u_{i,t}} \left(Z_{i,t}u_{i,t} - \Phi\left(u_{i,t}\right)\right) K_{i,t}$. The utilization choice is defined by the first order condition, $\Phi'\left(u_{i,t}\right) = Z_{i,t}$, up to a first-order approximation in deviation from steady states, $\frac{\Phi''(u)u}{\Phi'(u)}\hat{u}_{i,t} = \hat{z}_{i,t}$.

[24] National public spending are entirely home biased and consists of home varieties, *i.e.*, $P_{i,t}G_{i,t} = P_{i,t}(\int_0^1 G_{i,t}(i)^{(\epsilon_P-1)/\epsilon_P} di)^{\epsilon_P/(\epsilon_P-1)}$. The governement demand for home goods writes, $G_{i,t}(i) = \left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P} G_{i,t}$.

$P_{i,t}\bar{G}\varepsilon^G_{i,t}$. The balance sheet of governments writes:

$$P_{i,t}\bar{G}\varepsilon^G_{i,t} = \int_0^1 T_{i,t}(j)\,\mathrm{d}j + \tau^Y \int_0^1 P_{i,t}(i)\,Y_{i,t}(i)\,\mathrm{d}i + \tau^W \int_0^1 W_{i,t}(j)\,H_{i,t}(j)\,\mathrm{d}j$$
$$+ \tau^L \int_0^1 L^s_{i,t+1}(b)\,R^L_{i,t}(b)\,\mathrm{d}b + \tau^E \int_0^1 N^E_{i,t}(e)\,\mathrm{d}e + \tau^{BK} \int_0^1 BK_{i,t}(b)\,\mathrm{d}b,$$

where $G_{i,t}$ is the total amount of public spending in the i^{th} economy that follows and AR(1) shock process, $\tau^Y = (1-\epsilon_P)^{-1}$, $\tau^W = \left(1-\mu^W\right)$ and $\tau^L = \left(1-\mu^L\right)$ are taxes that mitigate the negative effects of monopolistic competition in steady states.

The central banks reacts to fluctuations in union wide measures of price and activity growths. The general expression of the interest rule implemented by the monetary union central bank writes:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho} \left[\left(\pi^C_{h,t}\pi^C_{f,t}\right)^{\phi^\pi} \left(\frac{Y_{h,t}Y_{f,t}}{Y_{h,t-1}Y_{f,t-1}}\right)^{\phi^{\Delta y}}\right]^{\frac{1}{2}(1-\rho)} e^{\varepsilon^R_t} \tag{4.29}$$

where ε^R_t is a AR(1) monetary policy shock process, ϕ^π is the inflation target parameter and $\phi^{\Delta y}$ is the GDP growth target.

4.6 Equilibrium conditions

In this model, there are in total 8 country specific structural shocks and one common shock in the Taylor rule. For $i \in \{h, f\}$, exogenous disturbances follow a first-order autoregressive process, $\varepsilon^s_{i,t} = \rho^s_i \varepsilon^s_{i,t-1} + \eta^s_{i,t}$ for $\forall s = \{U, A, Q, N, L, B\}$ and one common shock in the Taylor rule, $\varepsilon^R_t = \rho^R \varepsilon^R_{t-1} + \eta^R_t$. For the spending shock process, it is affected by the productivity shock as follows, $\varepsilon^G_{i,t} = \rho^G_i \varepsilon^G_{i,t-1} + \eta^G_{i,t} + \rho^{ag}_i \eta^A_{i,t}$; this assumption is empirically motivated as spending also includes net exports, which may be affected by domestic productivity developments (Smets & Wouters, 2007). The wage mark-up disturbance is assumed to follow an ARMA(1,1) process, $\varepsilon^W_{i,t} = \rho^W_i \varepsilon^W_{i,t-1} + \eta^W_{i,t} - u^W_i \eta^W_{i,t-1}$, where the MA term u^W_i is designed to capture the high-frequency fluctuations in wages. Finally, to catch up the co-moment in financial time series, we add common financial shocks η^s_t for $\forall s = \{Q, N, L, B\}$. We denote by ρ^U_i, ρ^A_i, ρ^G_i, ρ^Q_i, ρ^N_i, ρ^L_i, ρ^W_i, ρ^B_i and ρ^R the autoregressive terms of the exogenous variables, $\eta^U_{i,t}$, $\eta^A_{i,t}$, $\eta^G_{i,t}$, $\eta^Q_{i,t}$, $\eta^N_{i,t}$, $\eta^L_{i,t}$, $\eta^W_{i,t}$, $\eta^B_{i,t}$ and η^Q_t, η^N_t, η^L_t, η^B_t, η^R_t are standard errors that are mutually independent, serially uncorrelated and normally distributed with zero mean and variances $\sigma^2_{i,U}$, $\sigma^2_{i,A}$, $\sigma^2_{i,G}$, $\sigma^2_{i,Q}$, $\sigma^2_{i,N}$, $\sigma^2_{i,L}$,$\sigma^2_{i,W}$, $\sigma^2_{i,B}$ and , σ^2_Q, σ^2_N, σ^2_L, σ^2_B, σ^2_R respectively. A general equilibrium is defined as a sequence of quantities $\{\mathcal{Q}_t\}^\infty_{t=0}$ and prices $\{\mathcal{P}_t\}^\infty_{t=0}$ such that for a given sequence of quantities $\{\mathcal{Q}_t\}^\infty_{t=0}$ and the realization of shocks $\{\mathcal{S}_t\}^\infty_{t=0}$, the sequence

$\{\mathcal{P}_t\}_{t=0}^{\infty}$, guarantees the equilibrium on the capital, labor, loan, intermediate goods and final goods markets.

After (i) aggregating all agents and varieties in the economy, (ii) imposing market clearing for all markets, (iii) assuming that countries are mirror images of one another in terms of market openness[25], (iv) substituting the relevant demand functions, the resource constraint for the home country reads as follows:

$$\begin{aligned}\frac{Y_{h,t}}{\Delta^P_{h,t}} &= \left(1-\alpha^C\right)\left(\frac{P_{h,t}}{P^C_{h,t}}\right)^{-\mu} C_{h,t} + \alpha^C \left(\frac{P_{h,t}}{P^C_{f,t}}\right)^{-\mu} C_{f,t} \\ &+ \left(1-\alpha^I\right)\left(\frac{P_{h,t}}{P^I_{h,t}}\right)^{-\mu}\left(1+AC^I_{h,t}\right) I_{h,t} + \alpha^I \left(\frac{P_{h,t}}{P^I_{f,t}}\right)^{-\mu}\left(1+AC^I_{f,t}\right) I_{f,t} \\ &+ \bar{G}\varepsilon^G_{h,t} + AC^B_{h,t} + \left(1-\eta^E_{h,t}\right)\underline{\omega}_{h,t} Q_{h,t} K_{h,t} + \Phi\left(u_{h,t}\right) K_{h,t-1},\end{aligned} \tag{4.30}$$

where $\Delta^P_{i,t} = \int_0^1 (P_{i,t}(i)/P_{i,t})^{-\epsilon_P} \mathrm{d}i$ is the price dispersion term[26]. The aggregation of prices of the final goods sector leads to the expression:

$$P_{i,t}^{1-\epsilon_P} = \theta^P_i \left(P_{i,t-1}\pi_{i,t-1}^{\xi^P_i}\right)^{1-\epsilon_P} + \left(1-\theta^P_i\right)\left(P^*_{i,t}\right)^{1-\epsilon_P}. \tag{4.31}$$

Concerning unions, the aggregation of unions allowed and not allowed to reoptimize leads to the following expression of the aggregate wage index:

$$W_{i,t}^{\frac{1}{1-\mu^W_{i,t}}} = \theta^W_i \left[W_{i,t-1}\left(\pi^C_{i,t-1}\right)^{\xi^W_i}\right]^{\frac{1}{1-\mu^W_{i,t}}} + \left(1-\theta^W_i\right)\left(W^*_{i,t}\right)^{\frac{1}{1-\mu^W_{i,t}}}, \tag{4.32}$$

and the equilibrium on this market reads, $\int_0^1 H_{i,t}(j)\mathrm{d}j = \Delta^W_{i,t}\int_0^1 H^d_{i,t}(i)\mathrm{d}i$, where $\Delta^W_{i,t} = \int_0^1 \left(\frac{W_{i,t}(j)}{W_{i,t}}\right)^{-\mu^W_{i,t}/\left(\mu^W_{i,t}-1\right)}\mathrm{d}j$ is the wage dispersion term between different labor types.

The equilibrium on the home loan market reads:

$$L^s_{h,t+1} = \left(\left(1-\alpha^L\right)\left[\frac{R^L_{h,t}}{P^L_{h,t}}\right]^{-\nu} L^d_{h,t+1} + \alpha^L \left[\frac{R^L_{h,t}}{P^L_{f,t}}\right]^{-\nu} L^d_{f,t+1}\right)\Delta^L_{h,t},$$

[25] *i.e*, $\alpha^s_h = \alpha^s \Leftrightarrow \alpha^s_f = (1-\alpha^s)$ for markets $s = C, I, L, IB$ and the two countries are of equal size.

[26] To close the model, additional costs are entirely home biased, *i.e.* adjustment costs on bonds $AC^B_{i,t} = \left(\int_0^1 AC^B_{i,t}(i)^{(\epsilon_P-1)/\epsilon_P}\,\mathrm{d}i\right)^{\epsilon_P/(\epsilon_P-1)}$, insolvent investment projects of entrepreneurs and capital utilization costs from capital suppliers $K_{i,t} = \left(\int_0^1 K_{i,t}(i)^{(\epsilon_P-1)/\epsilon_P}\,\mathrm{d}i\right)^{\epsilon_P/(\epsilon_P-1)}$. The demands associated with the previous costs are, $AC^B_{i,t}(i) = \left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_P} AC^B_{i,t}$, $K_{i,t}(i) = \left(P_{i,t}(i)/P_{i,t}\right)^{-\epsilon_P} K_{i,t}$.

where $\Delta^L_{i,t} = \int_0^1 \left(\frac{R^L_{i,t}(b)}{R^L_{i,t}}\right)^{-\mu^L_{i,t}/(\mu^L_{i,t}-1)} db$ is the dispersion term of credit rates in the economy. The aggregation of loan prices writes:

$$\left(R^L_{i,t}\right)^{\frac{1}{1-\mu^L_{i,t}}} = \theta^L_i \left(R^L_{i,t-1}\left(\frac{R^L_{i,t-1}}{R^L_{i,t-2}}\right)^{\xi^L_i}\right)^{\frac{1}{1-\mu^L_{i,t}}} + \left(1-\theta^L_i\right)\left(R^L_{i,t}\right)^{\frac{1}{1-\mu^L_{i,t}}}.$$

On the perfectly competitive interbank market, the market clears when the following condition holds:

$$IB^s_{h,t+1} = \frac{\lambda}{1-\lambda}\left(\left(1-\alpha^{IB}\right)\left[\frac{R^{IB}_{h,t}}{P^{IB}_{h,t}}\right]^{-\xi} IB^d_{h,t+1} + \alpha^{IB}\left[\frac{R^{IB}_{h,t}}{P^{IB}_{f,t}}\right]^{-\xi} IB^d_{f,t+1}\right)$$

Asset market equilibrium implies that the world net supply of bonds is zero, the same applies to current accounts excess and deficits, $B_{h,t+1}+B_{f,t+1}=0$ and $CA_{h,t}+CA_{f,t}=0$, where home current account dynamic reads as follow:

$$\begin{aligned} CA_{h,t} = &\left(B_{h,t+1}-B_{h,t}\right)+\left[\left(L_{h,f,t+1}-L_{h,f,t}\right)-\left(L_{f,h,t+1}-L_{f,h,t}\right)\right] \\ &+\left[\left(IB_{h,f,t+1}-IB_{h,f,t}\right)-\left(IB_{f,h,t+1}-IB_{f,h,t}\right)\right]. \end{aligned}$$

5 Estimation

5.1 Data

The model is estimated with Bayesian methods on Euro Area quarterly data over the sample period 1999Q1 to 2013Q3. The dataset includes 17 time series: real GDP, real consumption, real investment, the ECB refinancing operation rate, the HICP, the real unit labor cost index, the real index of notional stocks of corporate and interbank loans, and the real borrowing cost of non-financial corporations. Data with a trend are made stationary using a linear trend and are divided by the population. We also demean the data because we do not use the information contained in the observable mean. Figure 4.4 plots the transformed data.

5.2 Calibration and Prior Distribution of Parameters

We fix a small number of parameters commonly used in the literature of real business cycles models in Table 4.1. These include the quarterly depreciation rate δ, the quarterly discount factor β, the capital share in the production α, the steady state of government expenditures in output $\bar{G}/\bar{Y}$ and the adjustment cost on portfolio $\mathcal{X}^B$ (Schmitt-Grohé

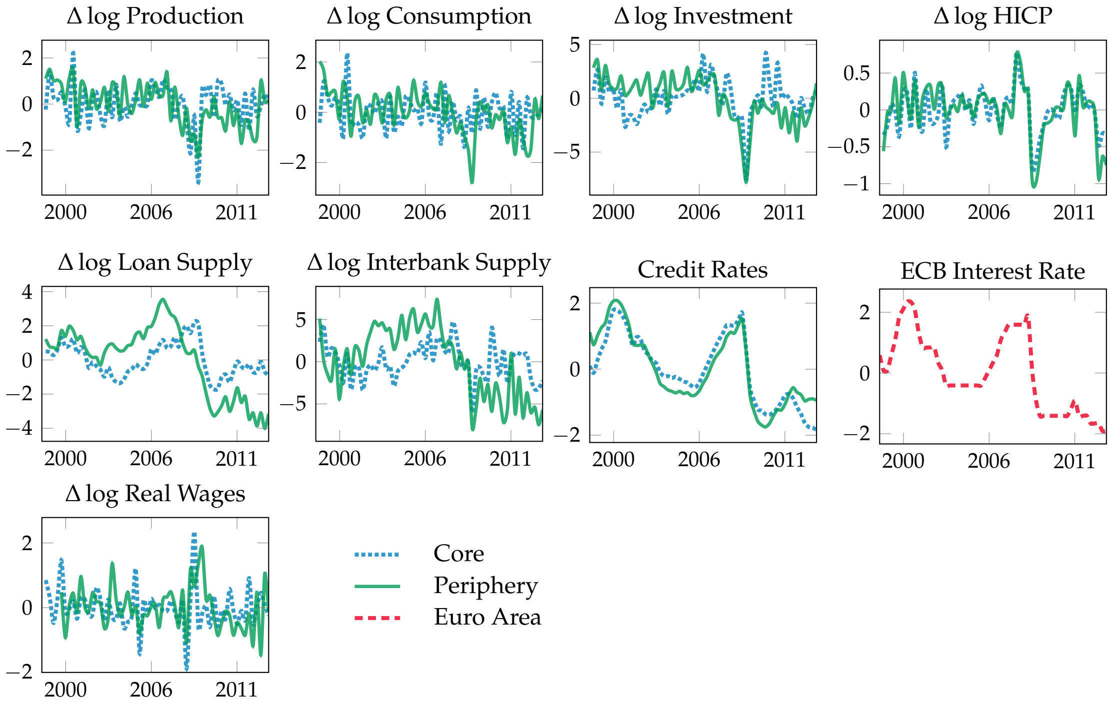


FIGURE 4.4: Observable variables used in the estimation

& Uribe, 2003). Under this calibration, the share of consumption and investment in the GDP is 56% and 20% respectively which is consistent with the Euro Area.

Regarding financial parameters, we fix the net worth to capital ratio of the private sector on the findings of Gerali et al. (2010), while the spread between the lending rate and the refinancing rate is calculated on the average observable variables used in the estimation for France and Germany and has a value of 200 points basis annually. We suppose that in steady state, the interbank rate in the Euro Area is equal to the refinancing rate $R = R_h^{IB} = R_f^{IB}$. Recall that following the Pareto distribution $\omega \sim \mathcal{P}(\kappa; \omega_{\min})$ where κ is the shape parameter and $\omega_{\min}$ the minimum value of $\omega \in [\omega_{\min}; +\infty[$. When ω^C hits the lower bound ($\omega^C = \omega_{\min}$), the economy is riskless implying $R^k = R^L = R$ so that when $\omega^C > \omega_{\min}$ there are financial frictions and defaulting entrepreneurs projects in the steady state. Given the first order condition of banks $R^L = R/\eta$, the conditions $E[\omega] = 1 = \frac{\kappa}{\kappa-1}\omega_{\min}$ and the definition of the share of gainful projects $\eta = \left(\omega_{\min}/\omega^C\right)^\kappa$, we compute κ and $\omega_{\min}$ via the following condition $\omega_{\min} = (\kappa - 1)/\kappa = 1 - \bar{N}/\bar{K}$. Calibrating the model without financial frictions ($\omega = \omega_{\min}$) and without loans ($L = 0$) makes the model really close to the Smets and Wouters model in a two-country set-up. From the previous calibration, we get the quarterly entrepreneur failure rate of $1 - \eta = 1.2\%$, which is comparable to Bernanke et al. (1999).

Our priors are listed in Table 4.3. Overall, they are either consistent with the previous literature or relatively uninformative. For a majority of new Keynesian models'

Parameter	Value	Description
β	0.995	Discount factor
δ	0.02	Depreciation rate
α	0.25	Capital share
$\bar{H}$	1/3	Share of hours worked per day
χ^B	0.07%	Portfolio adjustment costs
$\bar{G}/\bar{Y}$	0.24	Spending to GDP ratio
$\bar{N}/\bar{K}$	0.40	Net worth to capital ratio
$\overline{IB}/\bar{L}$	0.20	Interbank funds to lending ratio
$\overline{BK}/\bar{L}$	0.10	Bank capital to lending ratio
$\bar{R}^L - \bar{R}$	$0.02^{0.25}$	Loan spread

Table 4.1: Calibration of the model (all parameters are quarterly)

parameters, i.e. σ_i^C,. σ_i^L, h_i^C, θ_i^P, θ_i^W, ξ_i^P, ξ_i^W, χ_i^I, ψ_i, ϕ^π, $\phi^{\Delta y}$ and shocks processes parameters, we use the prior distributions chosen by Smets & Wouters (2003, 2007). Concerning international macroeconomic parameters, our priors are largely inspired by Lubik & Schorfheide (2006) for substitution parameters μ, ν and ξ. Regarding market openness, we use priors that are close to the observed degrees of openness: α^C, α^I, α^L and α^{IB} have a beta prior of means 0.10, 0.08, 0.08 and 0.20 and standard deviations of 0.04, 0.04, 0.04 and 0.07 respectively. For Calvo credit rates parameters, our priors are the same as the Calvo price priors. We set the prior for the elasticity of the external finance premium $\varkappa_i$ to a normal distribution with prior mean equal to 0.10 and standard deviation 0.05 consistent with previous financial accelerator estimations (De Graeve, 2008; Gilchrist, Ortiz, & Zakrajsek, 2009). For loan demand habits for firms and banks, we chose a very uninformative prior of mean 0.50 and standard deviation 0.20 with a beta distribution. Finally, the monitoring cost is set to a normal distribution with mean 0.50 and variance 0.20 which is consistent with Cúrdia & Woodford (2010).

		Prior distributions			Posterior distribution *[5%:95%]*		
		Shape	Mean	Std.	CORE	PERIPHERY	EURO
Productivity std	σ_i^A	$\mathcal{IG}$	0.10	2	0.88 [0.67:1.08]	0.76 [0.58:0.92]	-
Gov. spending std	σ_i^G	$\mathcal{IG}$	0.10	2	1.64 [1.37:1.90]	1.66 [1.39:1.93]	-
Preferences std	σ_i^U	$\mathcal{IG}$	0.10	2	1.59 [1.08:2.07]	2.12 [1.29:2.90]	-
Net Wealth std	σ_i^N	$\mathcal{IG}$	0.10	2	0.14 [0.08:0.21]	0.15 [0.06:0.23]	0.14 [0.08:0.19]
External Finance std	σ_i^Q	$\mathcal{IG}$	0.10	2	0.46 [0.03:0.78]	0.42 [0.03:0.79]	0.82 [0.64:1.01]
Bank cost-push std	σ_i^L	$\mathcal{IG}$	0.10	2	0.27 [0.03:0.48]	0.22 [0.02:0.47]	0.68 [0.45:0.90]
Bank Liab. std	σ_i^B	$\mathcal{IG}$	0.10	2	2.28 [1.77:2.78]	2.43 [1.80:3.03]	0.08 [0.02:0.16]
Wage cost-push std	σ_i^W	$\mathcal{IG}$	0.10	2	0.92 [0.56:1.24]	1.65 [0.86:2.47]	-
Monetary policy std	σ^R	$\mathcal{IG}$	0.10	2	-	-	0.09 [0.07:0.11]
Productivity AR	ρ_i^A	$\mathcal{B}$	0.85	0.10	0.99 [0.98:1.00]	0.99 [0.98:1.00]	-
Gov.spending AR	ρ_i^G	$\mathcal{B}$	0.85	0.10	0.93 [0.88:0.98]	0.91 [0.83:0.99]	-
Preferences AR	ρ_i^U	$\mathcal{B}$	0.85	0.10	0.81 [0.72:0.91]	0.54 [0.38:0.70]	-
Net Wealth AR	ρ_i^N	$\mathcal{B}$	0.85	0.10	0.96 [0.92:0.99]	0.96 [0.93:1.00]	-
Riskiness AR	ρ_i^Q	$\mathcal{B}$	0.85	0.10	0.47 [0.35:0.59]	0.59 [0.47:0.71]	-
Bank cost-push AR	σ_i^L	$\mathcal{B}$	0.85	0.10	0.99 [0.98:1.00]	0.90 [0.84:0.96]	-
Bank Liab. AR	ρ_i^B	$\mathcal{B}$	0.85	0.10	0.90 [0.83:0.97]	0.93 [0.88:0.99]	-
Wage cost-push AR	σ_i^W	$\mathcal{B}$	0.85	0.10	0.99 [0.99:1.00]	0.99 [0.99:1.00]	-
Wage MA term	u_i^W	$\mathcal{B}$	0.85	0.10	0.51 [0.26:0.77]	0.28 [0.07:0.49]	-
Taylor AR	ρ_i^R	$\mathcal{B}$	0.85	0.10	-	-	0.41 [0.29:0.52]
Productivity-Spending	ρ_i^{ag}	$\mathcal{B}$	0.85	0.10	0.84 [0.69:0.99]	0.83 [0.69:0.99]	-

Table 4.2: Prior and Posterior distributions of shock processes

5.3 Posterior Estimates

The methodology is standard to the Bayesian estimation of DSGE models[27]. Figure 4.5 reports the prior and posterior marginal densities of the parameters of the model, excluding the standard deviation of the shocks and the parameters driving the shocks processes. In Figure 4.5, the data were relatively informative except for a small numbers of parameters for which the posterior distribution stay very close to the chosen priors. These parameters are the risk consumption parameter σ_i^C, the elasticity of the

[27] Interest rates data are associated with one-year maturity loans, we take into account this maturity by multiplying by 4 the rates in the measurement equation. The number of shocks is higher (or equal) to observable variables to avoid stochastic singularity issue. Recalling that $i \in \{h, f\}$, the vectors of observables $\mathcal{Y}_t^{obs} = \left[\Delta\log\tilde{Y}_{i,t}, \Delta\log\tilde{C}_{i,t}, \Delta\log\tilde{I}_{i,t}, R_t, \Delta\log HICP_{i,t}, \Delta\log W_t, \Delta\log\tilde{L}_{i,t}^s, R_{i,t}^L, \Delta\log\widetilde{IB}_{i,t}^s\right]'$ and measurement equations $\mathcal{Y}_t = \left[\hat{y}_{i,t}-\hat{y}_{i,t-1},\ \hat{c}_{i,t}-\hat{c}_{i,t-1},\ \hat{\imath}_{i,t}-\hat{\imath}_{i,t-1},\ 4\times\hat{r}_t,\ \hat{\pi}_{i,t}^c, \hat{w}_t-\hat{w}_{t-1},\ \hat{l}_{i,t}^s-\hat{l}_{i,t-1}^s,\ 4\times\hat{r}_{i,t}^L,\ \widetilde{ib}_{i,t}^s-\widetilde{ib}_{i,t-1}^s\right]'$, where Δ denotes the temporal difference operator, $\tilde{X}_t$ is per capita variable of X_t. The model matches the data setting $\mathcal{Y}_t^{obs} = \overline{\mathcal{Y}} + \mathcal{Y}_t$ where $\overline{\mathcal{Y}}$ is the vector of the mean parameters, we suppose this is a vector of all 0. The posterior distribution combines the likelihood function with prior information. To calculate the posterior distribution to evaluate the marginal likelihood of the model, the Metropolis-Hastings algorithm is employed. To do this, a sample of 400,000 draws was generated, neglecting the first 50,000. The scale factor was set in order to deliver acceptance rates of between 20 and 30 percent. Convergence was assessed by means of the multivariate convergence statistics taken from Brooks & Gelman (1998).

		Prior distributions			Posterior distribution *[5%:95%]*		
		Shape	Mean	Std.	CORE	PERIPHERY	EURO
Cons. aversion	σ_i^C	$\mathcal{N}$	2	0.30	2.00 [1.56:2.45]	2.04 [1.57:2.49]	-
Cons. inertia	h_i^C	$\mathcal{B}$	0.7	0.10	0.32 [0.21:0.42]	0.57 [0.46:0.68]	-
Labour disutility	σ_i^L	$\mathcal{G}$	1	0.30	0.59 [0.30:0.88]	0.66 [0.36:0.96]	-
Calvo prices	θ_i^P	$\mathcal{B}$	0.5	0.10	0.56 [0.47:0.65]	0.56 [0.47:0.65]	-
Indexation prices	ξ_i^P	$\mathcal{B}$	0.5	0.2	0.07 [0.01:0.14]	0.08 [0.01:0.16]	-
Calvo wages	θ_i^W	$\mathcal{B}$	0.5	0.10	0.67 [0.56:0.78]	0.6 [0.49:0.72]	-
Indexation wages	ξ_i^W	$\mathcal{B}$	0.5	0.10	0.46 [0.16:0.76]	0.36 [0.07:0.64]	-
Calvo banks rates	θ_i^L	$\mathcal{B}$	0.5	0.10	0.29 [0.20:0.38]	0.31 [0.18:0.43]	-
Indexation bank rates	ξ_i^L	$\mathcal{B}$	0.5	0.15	0.12 [0.01:0.22]	0.21 [0.05:0.37]	-
Investment adj. costs	χ_i^I	$\mathcal{N}$	4	1.5	0.63 [0.38:0.86]	1.87 [1.16:2.58]	-
Monitoring cost	χ_i^{IB}	$\mathcal{N}$	0.5	0.2	0.48 [0.28:0.68]	0.23 [0.00:0.48]	-
Capital utilization	ψ_i	$\mathcal{B}$	0.5	0.15	0.66 [0.47:0.85]	0.68 [0.51:0.86]	-
EF. Premia Elasticity	$\varkappa_i$	$\mathcal{B}$	0.1	0.05	0.05 [0.01:0.09]	0.08 [0.02:0.15]	-
Firms loans habits	h_i^L	$\mathcal{B}$	0.5	0.2	0.96 [0.93:0.99]	0.95 [0.92:0.98]	-
Interbank loans habit	h_i^B	$\mathcal{B}$	0.5	0.2	0.20 [0.05:0.34]	0.21 [0.07:0.35]	-
Illiquid bank share	λ	$\mathcal{B}$	0.5	0.08	-	-	0.25 [0.20:0.29]
MPR smoothing	ρ	$\mathcal{B}$	0.85	0.10	-	-	0.84 [0.81:0.88]
MPR Inflation	ϕ^π	$\mathcal{N}$	2	0.15	-	-	1.85 [1.60:2.10]
MPR GDP	$\phi^{\Delta y}$	$\mathcal{N}$	0.12	0.05	-	-	0.15 [0.08:0.23]
Cons. openness	α^C	$\mathcal{B}$	0.10	0.04	-	-	0.17 [0.11:0.23]
Investment openness	α^I	$\mathcal{B}$	0.08	0.04	-	-	0.06 [0.01:0.10]
Corporate openness	α^L	$\mathcal{B}$	0.08	0.04	-	-	0.09 [0.03:0.15]
Interbank openness	α^{IB}	$\mathcal{B}$	0.2	0.07	-	-	0.11 [0.05:0.17]
Subst. final good	μ	$\mathcal{G}$	1	0.75	-	-	4.43 [3.09:5.75]
Subst. corporate loan	ν	$\mathcal{G}$	1	0.75	-	-	2.02 [0.03:4.07]
Subst. interbank loan	ξ	$\mathcal{G}$	1	0.75	-	-	0.87 [0.02:1.75]

TABLE 4.3: Prior and Posterior distributions of structural parameters

external premium for peripheral countries $\varkappa_f$, the inflation and GDP growth penalization degrees in the Taylor rule ϕ^π and $\phi^{\Delta y}$, the elasticity for loans ξ, ν and the financial openness α^L for the corporate sector[28]. We investigate the sources of non identification for these parameters using methods developed by Saltelli et al. (2008), Andrle (2010) and Iskrev (2010). We find that the low identification of parameters driving the risk aversion coefficient σ_i^c and the substitutions of loans ν and ξ is due to their small impacts on the likelihood. As An & Schorfheide (2007), we find that the the Taylor rule smoothing ρ is the best identified parameter, and that it strongly interacts with other parameters in the Taylor rule ϕ^π and $\phi^{\Delta y}$. Indeed, using the brute force search à la Iskrev (2010),

[28]The elasticity of intertemporal substitution, inflation weight and output growth in the monetary policy rule are parameters that are frequently not well identified, see for exemple An & Schorfheide (2007) or Kolasa (2008).

	w/ common financial shocks		w/o common financial shocks	
	$\mathcal{M}_1(\theta)$	$\mathcal{M}_2(\theta)$	$\mathcal{M}_1(\theta)$	$\mathcal{M}_2(\theta)$
	autarky	*globalization*	*autarky*	*globalization*
Prior probability	1/2	1/2	1/2	1/2
Laplace approximation	-1392.0	-1389.5	-1432.1	-1412.1
Posterior odds ratio	1.00	13.5	1.00	4.7×10^8
Posterior model probability	0.07	0.93	0	1.00

Table 4.4: Prior and posterior model probabilities

we note a correlation link that involves ϕ^π, $\phi^{\Delta y}$ with ρ[29]. We also find a partial confounding with the elasticity of the external premium $\varkappa_f$ and the credit rate stickiness θ_f^L: since the external finance premium is mainly driven by the monetary policy shock (De Graeve, 2008), the introduction of Calvo credit rate weakens the identification of the external finance premium as monetary policy shocks are dampened when rates are sticky. Finally, even if the market openness α^L stay very close to the prior, identification methods show that α^L is accurately identified (even better than α^C)[30].

The posterior parameters' differences or similarities between core and peripheral countries provide the microfoundations for national asymmetries as shown in Table 4.3 and in Table 4.2. Concerning shocks parameters, there is one noticeable difference between core and periphery in the persistence of riskiness shocks, any change in the expectations of the private sector lasts more in periphery. Regarding structural parameters, real frictions are more important in periphery as consumption habits, capital utilization elasticity and investment costs are higher. Turning to nominal frictions, core and periphery face similar price rigidities as Calvo and indexation parameters for prices are nearly equal, while wage rigidities are more pronounced in core countries. Finally for financial frictions, the pass-through of the policy rate is not surprisingly better in core countries as Calvo and indexation parameters for credit rate are lower than in periphery. According to the elasticity of external premium, peripheral firms are more optimistic than core. The monitoring technology is better for peripheral liquid banks. For the Euro area parameters, the banking system is composed of 25% of banks in need of interbank funds. Concerning market openness parameters, they are consistent with the data and close to the findings of Eyquem & Poutineau (2010) for α^C and α^I while the market openness of the interbank market is a slightly lower than its value observed in Figure 4.2.

Since we are interested in finding evidence that cross-border loans significantly explain a part of the business cycles, we consider θ the vector of the estimated parameters of

[29]See An & Schorfheide (2007) for further explanations on this correlation link.
[30]Parameter α^L does not involve any important correlation link with other parameter, its log-likelihood is not flat and is not a weak element of the parameter set.

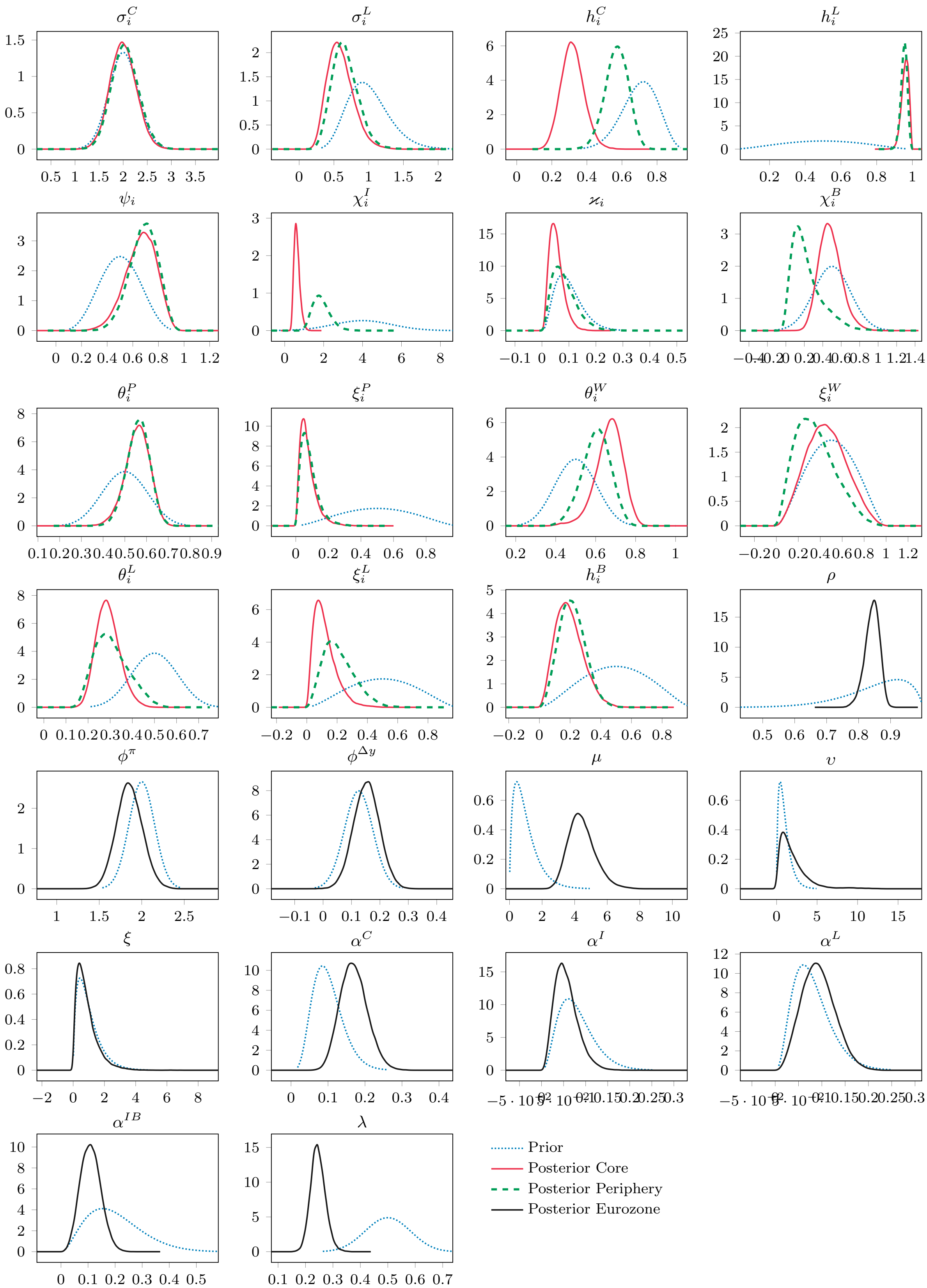


FIGURE 4.5: The priors and posteriors distributions of the model parameters with cross-border banking flows.

the model $\mathcal{M}(\theta)$ presented in Section 3 and we estimate $\mathcal{M}(\theta)$ under two scenarii: in $\mathcal{M}_1(\theta)$ there is no cross-border lending flows between countries so that, $\alpha^L = \alpha^{IB} = 0$, $\nu = \xi = 0$; in $\mathcal{M}_2(\theta)$ we introduce cross-border lending flows between countries by estimating α^L, $\alpha^{IB} \in [0,1]$, $\nu, \xi \geq 0$. At last, we are interested in finding evidence that cross-border loans significantly explain a part of the business cycles of the Eurozone. Put differently, we examine the hypothesis H_0: $\alpha^L = \alpha^{IB} = 0$, $\nu = \xi = 0$ against the hypothesis H_1: α^L, $\alpha^{IB} \in [0,1)$, $\nu, \xi > 0$, to do this we evaluate the posterior odds ratio of $\mathcal{M}_2(\theta)$ on $\mathcal{M}_1(\theta)$ using Laplace-approximated marginal data densities. The posterior odds of the null hypothesis of no significance of banking flows is 13.5:1 which leads us to strongly reject the null, *i.e.* cross-border lending flows do matter in explaining the business cycles of the Euro Area. This result is confirmed in terms of log marginal likelihood. When the models are estimated without common financial shocks, then cross-border flows have an even more important role in explaining the business cycles as the posterior odds ratio becomes 4.7×10^8:1.

6 The Consequences of Cross-border Loans

Once the model has been estimated, we evaluate the consequences of cross-border lending on the national and international transmission of asymmetric shocks. We report the Bayesian IRFs obtained from linearized models $\mathcal{M}_1$ and $\mathcal{M}_2$. We concentrate on three main shocks that affect the core countries: an asymmetric productivity shock affecting firms, an asymmetric financial shock that reduces the net worth of entrepreneurs and a positive shock affecting the liquidity situation of the banking system.

6.1 A Positive Shock on Total Factor Productivity

Figure 4.6 (page 128) reports the simulated responses of the main macroeconomic and financial variables following a positive shock to $\varepsilon^A_{h,t}$ equal in size to the standard deviation of total factor productivity estimated in Table 4.3.

In the benchmark situation (dotted line), loan markets are segmented. As standardly documented in the literature, this productivity shock increases production, consumption and investment while decreasing the inflation rate in the core countries (Smets & Wouters, 2003). This shock is transmitted to peripheral economies through the terms of trade, the current account and the reaction of the central bank interest rate. The deterioration of the core countries' terms of trade increases the relative competitiveness and the exports of core countries goods towards peripheral economies. The decrease of the relative price of core countries goods depresses peripheral activity and investment. The average union wide rate of consumption price inflation decreases, which leads the central bank to reduce the interbank interest rate (Eyquem & Poutineau, 2010). As

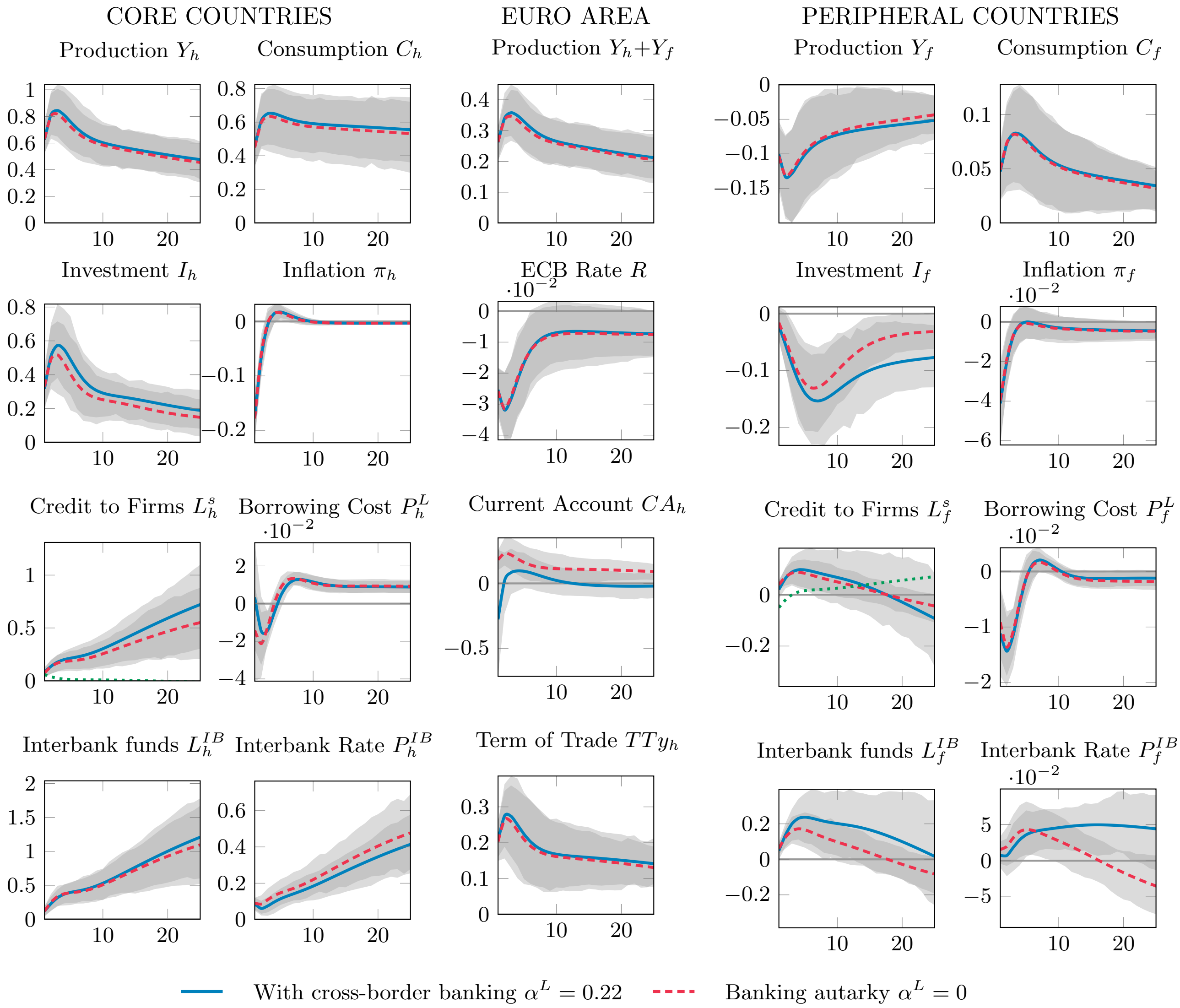


FIGURE 4.6: Bayesian system response to an estimated positive productivity shock in core countries under banking globalization ($\alpha^L = 9\%$, $\alpha^{IB} = 11\%$) and autarky ($\alpha^L = \alpha^{IB} = 0\%$)

observed, corporate loans increase in both countries. In core countries, entrepreneurs contract more loans to finance new investment flows after the positive supply shock. Central bank reaction affects the banking system through the decrease of the interest rate. This, in turn, lowers the interest rate on loans and increases corporate loan demand. As observed, interbank lending also rises to allow illiquid banks to meet the increased corporate loan demand. This increase in corporate loan demand dampens the decrease in investment as all the new loans remain in the periphery. However the rise in firm leverage increases the failure rate of investment projects in both countries and by so, the interest rate served by banks increases after 5 quarters. Thus, the segmentation of the loan market has a clear dampening effect in the periphery with regards to the transmission of core countries' productivity shocks.

The possibility of banks to engage in cross-border lending (plain lines) acts as a mechanism that mainly increases the dispersion of investment cycles in the monetary union. As cross-border lending improves the international allocation of financial resources in the monetary union, it amplifies the positive impact on investment in core countries and the negative impact in the peripheral economies, while leaving unaffected the dynamics of consumption and activity in both part of the monetary union. As a consequence, the current account adjustment (that reflects net savings) is significantly affected by the assumption regarding the degree of cross-border banking. Part of the increase in domestic investment is fuelled by foreign loans: the increase in foreign lending increases (partly financed by an increase in interbank lending in the peripheral countries). This implies a net increase in foreign loan supply after 5 quarters with regard to the segmented situation. By lending to more productive domestic firms, the foreign banking system has access to more reliable borrowers. Cross-border lending clearly impacts negatively the foreign macroeconomic performance, as more lending resources are diverted towards the domestic economy. This is clearly shown by the increased slump in peripheral countries' investment. With cross-border relations, the increase in interbank lending is reflected by a decrease in core countries' loan supply. Part of the liquidity of domestic banks comes from peripheral banks, through cross-border interbank lending.

Cross-border lending significantly affects the dynamics of the current account. Ignoring cross-border banking, the adjustment of the current account is standard, as the domestic economy experiences a surplus of net exports, that depicts the intertemporal allocation of the increase in national resources over a sample time period of thirty quarters. Cross-border loans clearly deteriorate core countries' current account with respect to the benchmark situation (dotted lines). As activity and consumption remain unaffected by the integration of the loan market, and as the increase of investment is higher in the core countries (while the decrease in investment is higher in peripheral countries), the current account of core countries deteriorates with respect to the segmented situation, to reflect the increased dispersion of investment cycles. Finally, the IRFs of the terms of trade and of the central bank interest rate are unaffected by cross-border lending.

6.2 A Negative Shock on Firms Net Worth

The second set of IRFs, reported in Figure 4.7 (page 132), describes the consequences of a negative shock on core countries' firm net worth $\varepsilon^N_{h,t}$. This negative shock can be thought of as an overnight decrease in the value of investor capital (following, for example a stock exchange collapse).

Without cross-border loans (dotted lines), a reduction in firms' net worth depresses investment and production and is deflationary in core countries. The reduction of activity is driven by the decrease in investment decisions. The central bank reacts to deflation by decreasing the interbank interest rate. This, in turn, increases consumption and dampens the negative impact on core countries' investment after 4 periods. As investment decreases more than activity, consumption increases and, as core countries' inflation rate decreases more than peripheral inflation rate, the domestic terms of trade deteriorates. As a consequence, more domestic goods are exported and consumed by peripheral households. The production of foreign goods decreases which, in turn, implies a decrease in investment decisions. In the meanwhile, following the decrease in the ECB central bank interest rate, peripheral consumption increases (this increase falls on imported goods). Initially, the negative wealth shock increases the probability of insolvent projects, and leads to higher interest rates on loans, despite the reduction of the central bank interest rate. This, in turn depresses investment. As observed, since banks engage in less corporate loans, their liquidity situation improves and interbank lending decreases. The improvement in core countries' current account reflects the increase in net savings coming from the decrease of investment in this part of the monetary union. Finally, interbank loans remain almost unaffected in peripheral countries.

Cross-border bank activity (plain lines) acts as a mechanism that amplifies the negative financial shock in core countries while it improves the situation of the periphery. The positive impact observed on peripheral investment comes from the fact that part of core countries's loans are diverted towards the periphery. This net inflow of loans in the periphery fuels firm investment. The second phenomenon is the drop in interbank loans: now part of corporate loans is directly distributed by core countries' banks to peripheral entrepreneurs. This phenomenon is reinforced by the fact that the borrowing cost of corporate loans is cheaper in the periphery with cross border loans, with respect to the segmented situation. Thus, as banks engage in cross-border loans towards peripheral firms, they lend less to core countries' firms, which furthermore depresses investment and activity in this part of the monetary union.

Taken globally, the macroeconomic performance of the currency union worsens with cross-border bank lending, as activity slightly decreases with respect to the segmented situation. The combination of a higher deterioration of the core countries terms of trade and decrease in domestic investment improves the current account of core countries. Thus cross-border lending clearly amplifies the diffusion of a negative net worth shock in the monetary union. It also increases the heterogeneity of investment cycles and the dispersion of current account positions. Negative consequences of net worth shocks have already been studied in the literature with financial globalization (Ueda, 2012) and without (Hirakata et al., 2011). Our results are in line with this literature.

6.3 A Positive Shock on Bank Resources

The third set of IRFs, reported in Figure 4.8 (page 134), describes the consequences of a positive shock on bank resources $\varepsilon^{B}_{h,t}$. This positive shock represents an increase in the resources of the core countries' banking system. It improves the liquidity situation of the core countries' banking system which in turn implies the creation of more corporate loans and reduces the need for interbank loans.

Without cross-border loans (dotted lines), this shock induces an increase in core countries' investment, which in turn leads to more activity. However, as it generates a positive demand shock (the increase in investment is higher than that of activity), it leads to more inflation and to an initial improvement in the terms of trade of core countries. This last phenomenon deteriorates the price competitiveness of core countries' goods while increasing that of peripheral goods. As a consequence, activity increases in the peripheral economies. In the meanwhile as this shock implies an increase in the average inflation rate of the monetary union, the central bank reacts by increasing its interest rate, which in turn depresses consumption and leads to a decrease in activity and inflation after 5 periods in core countries. Lending decisions in the periphery can be explained as follows: the increase in the interest rate of the central bank affects positively the interest rate on loans which in turn depresses loan demand in the periphery. As a consequence, the increase in peripheral investment is financed by peripheral entrepreneur net wealth.

Cross-border bank activity (plain lines) acts as a mechanism that amplifies the transmission of the core country shock on peripheral countries' investment. Now, peripheral entrepreneurs have access to domestic corporate loans which increases peripheral investment. With cross-border lending, interbank developments should be understood as

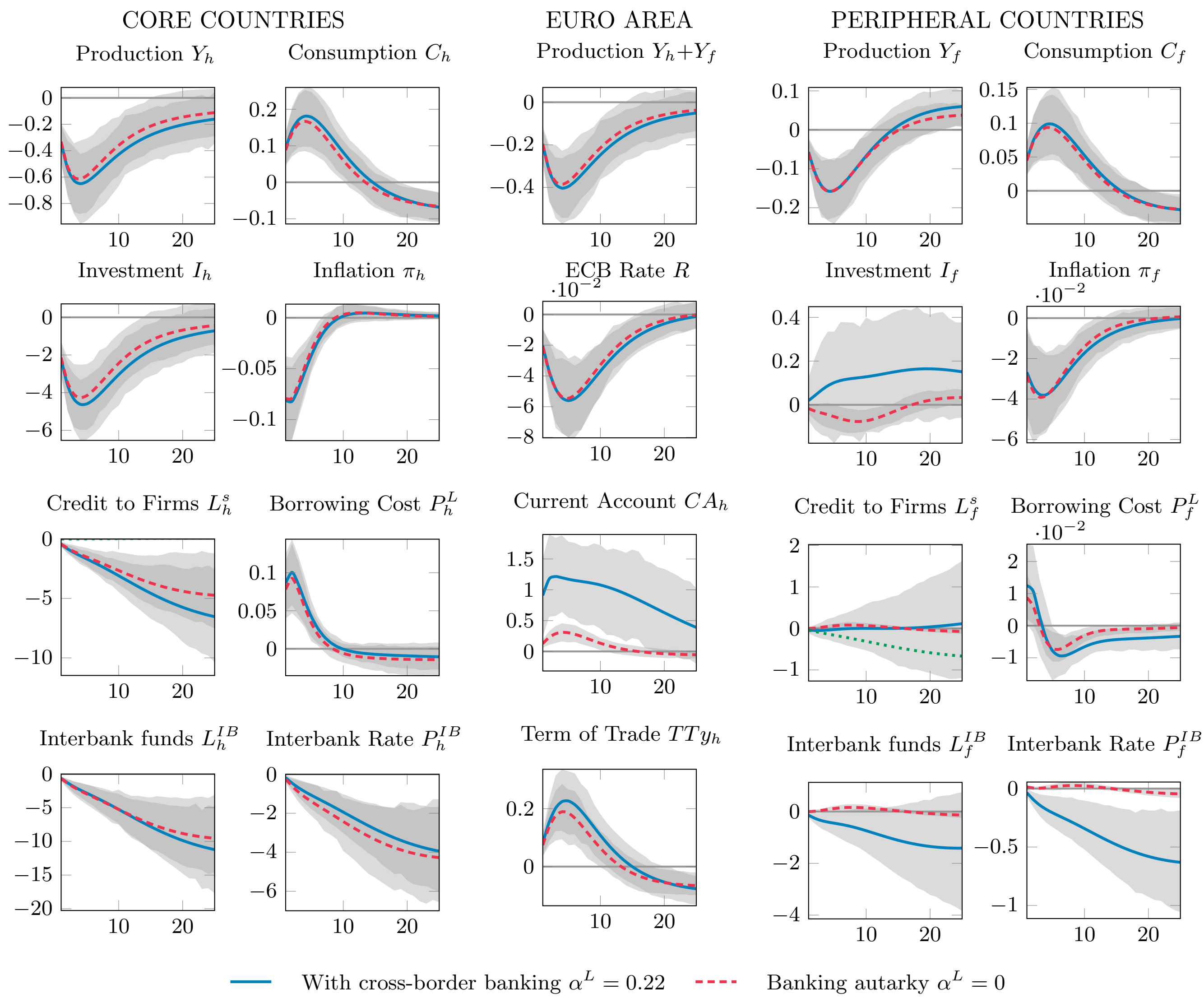


FIGURE 4.7: Bayesian system response to an estimated negative net wealth shock in core countries under banking globalization ($\alpha^L = 9\%$, $\alpha^{IB} = 11\%$) and autarky ($\alpha^L = \alpha^{IB} = 0\%$)

follows: the further decrease in interbank loans and higher increase in peripheral countries interbank lending clearly fuels investment in the periphery. The increase in the supply of corporate loans is channelled though the increase in interbank lending and the increase in cross-border bank lending (more decrease in the core countries' interbank loans). Initially more corporate loans are distributed in the periphery. However, as it leads to an increase in the leverage ratio of firms, it increases the probability of unproductive projects and, by so, increases the interest rate on loans after 4 periods. This, in turn, depresses peripheral investment after 4 periods.

Cross border banking impacts the dynamics of the bilateral current account. As the dynamics of investment in the periphery is reversed between segmented and integrated situations, it clearly affects the time path of investment and, by so, the time path of the current account. This reaction of investment more than compensate the impact of the terms of trade improvement that leads to the current account deficit in the situation with segmented loan markets.

7 The Driving Forces of Business and Credit Cycles

7.1 The Historical Variance Decomposition

Table 4.5 reports the posterior variance decomposition of the main aggregates (rate of growth of activity, consumption, investment and loan supply), the average interest rate paid by borrowers, the interest rate of the central bank and the current account. To evaluate the consequences of cross-border interbank and corporate loans, we contrast the variance decomposition reported for model $\mathcal{M}_2$ with corresponding benchmark figures reported for $\mathcal{M}_1$ under loan market segmentation. To see the role played by the shocks on these evolutions, we decompose each aggregate variations into the proportions explained by supply shocks (we aggregate $\eta^A_{i,t}$ and $\eta^W_{i,t}$), demand shocks (we aggregate $\eta^U_{i,t}$ and $\eta^G_{i,t}$), financial shocks (we aggregate $\eta^N_{i,t}$, $\eta^Q_{i,t}$, $\eta^B_{i,t}$ and $\eta^L_{i,t}$) and the monetary policy shock (η^R_t).

As reported, most of the variance of the growth rate of activity, consumption and inflation is explained by real supply shocks, while the variance of investment, loan supply and interest rates are mainly affected by national financial shocks. These results are in line with the ones reported by Hirakata et al. (2011). Remarkably, the contribution of financial shocks to the fluctuations in the rate of interbank and corporate loan growth rate are comparable (respectively around 46% and 48%).

Besides these general features, our model reports national heterogeneities regarding financial and real supply shocks. On average, financial shocks have a higher impact on core countries' variables than on peripheral variables. As an example, the contribution of

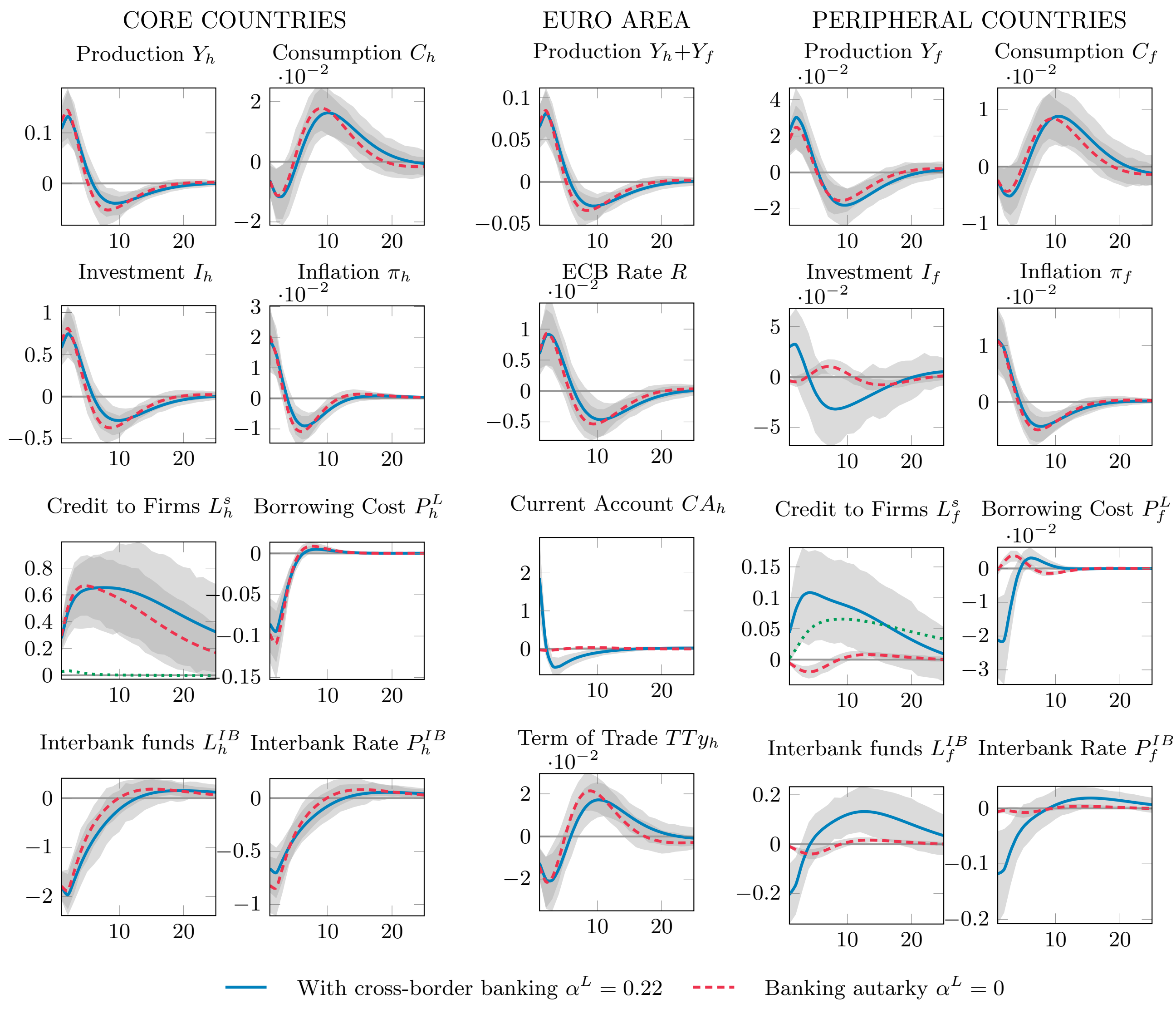


FIGURE 4.8: Bayesian system response to an estimated positive liability shock in the balance sheet of core countries banks under banking globalization ($\alpha^L = 9\%$, $\alpha^{IB} = 11\%$) and autarky ($\alpha^L = \alpha^{IB} = 0\%$)

the financial shocks accounts respectively for 14.6% and 1.7% of the variance of activity and consumption in core countries, while it accounts for respectively 10.0% and 1.2% in the periphery. As a main noticeable exception core investment is less affected by financial shock than peripheral investment (50.1% instead of 51.4%). For activity and consumption, real supply shocks have a stronger impact on peripheral aggregates.

As observed, fluctuations in financial indicators related to lending decisions are deeply affected by financial shocks. Contrasting the relative contribution of national, cross-border and common financial shocks, we find that with the noticeable exception of investment (mainly affected by national shocks), variables are mainly affected by common shocks. In contrast, cross-border shocks have only a marginal contribution to the fluctuations of the variables of interest. In most cases, cross-border financial shocks have a higher contribution than cross-border real supply and demand shocks. The main impact of cross-border shocks is observed for financial shocks on financial variables. As an example, peripheral financial shocks account for 7.9% of the fluctuation of core countries' corporate loan interest rate. As reported, leaving aside activity, core countries variables are more altered by cross-border shocks than peripheral variables .

We evaluate how the transmission of shocks is affected by cross-border loans by contrasting these general findings with the lower part of Table 4.5. As reported, cross-border banking has a stabilizing effect on financial shocks for activity and consumption (this affects all dimensions of the financial shocks) but increases the contribution of the financial shocks on the fluctuations of the growth rate of investment. Evidence is mixed for other national variables. However has reported, core countries get a higher profit from the integration of the loan market in the Eurozone, as we observe more reduction in the contribution of national financial shocks on national indicators (for 12 variables instead of 9 for peripheral countries). Thus, cross-border lending has a per-se impact on the diffusion of financial shocks as it significantly reduces the contribution of national financial shocks on the fluctuations of national variables.

Finally, contrasting the two models, we find that cross-border lending reduces the contribution of financial shocks to the fluctuations in the central bank interest rate (it explains 71.4% of the interest rate fluctuations instead of 77.6% if the loan market is segmented).

7.2 Understanding the Time Path of the Current Account

The last rows devoted to the models $\mathcal{M}_2$ and $\mathcal{M}_1$in Table 4.5 present the variance decomposition of current account fluctuations. As reported, it is clearly affected by the integration of the loan market: under loan market segmentation, financial shocks contribute to 57.6% of current account fluctuations, while they account for 91.8% with cross-border banking. Remarkably, the contribution of both national and common shocks increase.

	CORE			PERIPHERY			EURO	
	Supply	Demand	Financial	Supply	Demand	Financial	Common Financial	Monetary Policy
With cross-border flows								
$V(\Delta Y_{core})$	47.2	12.5	14.6	0.9	1.9	0.6	20.4	1.9
$V(\Delta C_{core})$	70.5	18.2	1.7	0.9	0.6	0.8	4.4	2.8
$V(\pi_{core})$	24.9	18.6	12.6	1.5	2.2	5.4	20.1	14.7
$V(\Delta I_{core})$	1.2	0.3	50.1	0.1	0	0.4	47.5	0.4
$V(\Delta L^s_{core})$	1.3	0.1	46.6	0.2	0.1	1	50.2	0.5
$V\left(R^L_{core}\right)$	18.6	0.5	26.8	1.6	0.1	1.1	49.2	2.2
$V(\Delta IB^s_{core})$	0.9	0.1	48.7	0.2	0.1	1	48.6	0.5
$V\left(P^{IB}_{core}\right)$	15	0	37.3	0.4	0	0.8	46.5	0
$V(\Delta Y_{peri})$	1.2	2	1.1	53	14.8	10	17	0.8
$V(\Delta C_{peri})$	0.4	0.5	0.4	76.3	17.4	1.2	2.7	1.1
$V(\pi_{peri})$	1.5	3.1	3.9	24.4	19.3	10.5	21.8	15.6
$V(\Delta I_{peri})$	0.1	0	0.1	1.5	0.2	51.4	46.6	0.1
$V\left(\Delta L^s_{peri}\right)$	0.1	0.1	0.3	2	0.1	46.1	50.8	0.4
$V\left(R^L_{peri}\right)$	0.4	0.1	0.3	51.1	0.3	15.3	31.2	1.2
$V\left(\Delta IB^s_{peri}\right)$	0.1	0.1	0.5	1.7	0.1	48.9	48.3	0.3
$V\left(P^{IB}_{peri}\right)$	0.1	0	0.8	47.9	0	23	28.2	0
$V(R)$	6	9.3	11.8	5.9	5.3	14	45.6	2.1
$V(CA)$	0.4	0.6	32.3	1.7	0.2	58.9	6	0
Without cross-border flows								
$V(\Delta Y_{core})$	45	10.3	16.3	0.5	1.3	0.9	23.8	1.7
$V(\Delta C_{core})$	75.3	13.1	2	0.4	0.5	1.2	4.8	2.6
$V(\pi_{core})$	20.4	15.9	15.6	1	2	6.4	23.4	15.3
$V(\Delta I_{core})$	1.3	0.3	48.9	0	0	0	49.1	0.4
$V(\Delta L^s_{core})$	1.3	0.1	48	0.1	0.1	0.1	49.9	0.3
$V\left(R^L_{core}\right)$	18.9	0.2	30.4	0.3	0.1	0.1	48.5	1.5
$V(\Delta IB^s_{core})$	1.2	0.1	57	0.1	0.1	0.1	41.2	0.3
$V\left(P^{IB}_{core}\right)$	19.6	0	34.6	0.2	0	0	45.5	0
$V(\Delta Y_{peri})$	0.8	1.7	1.4	49.9	13.5	10.9	21.1	0.8
$V(\Delta C_{peri})$	0.2	0.5	0.6	78.3	14.7	1.5	3	1.1
$V(\pi_{peri})$	1.1	3	5.2	19.6	16.2	12.3	26.2	16.4
$V(\Delta I_{peri})$	0	0	0	1.4	0.2	48.7	49.5	0.1
$V\left(\Delta L^s_{peri}\right)$	0.1	0.1	0.1	1.4	0.2	43.3	54.7	0.3
$V\left(R^L_{peri}\right)$	0.2	0	0.1	46.7	0.2	10.6	41.4	0.8
$V\left(\Delta IB^s_{peri}\right)$	0.1	0.1	0.1	1.3	0.2	50.9	47.3	0.2
$V\left(P^{IB}_{peri}\right)$	0.1	0	0	33	0	38.5	28.5	0
$V(R)$	3.8	8.6	13.8	3.6	4.5	17.2	46.6	1.9
$V(CA)$	9.8	16.3	20.5	8	8.3	33.4	3.7	0

TABLE 4.5: The unconditional variance decomposition is the share of variance accounted for by each shock of the model estimated with and without cross-border flows.

Note: Supply: productivity ($\eta^A_{i,t}$) and wage cost-push ($\eta^W_{i,t}$); Demand: preferences ($\eta^\beta_{i,t}$) and spending ($\eta^G_{i,t}$); Financial: collateral ($\eta^N_{i,t}$), riskiness ($\eta^Q_{i,t}$) credit rate cost-push ($\eta^L_{i,t}$), and liabilities ($\eta^B_{i,t}$); Common financial: collateral (η^N_t) riskiness (η^Q_t) rate cost-push (η^L_t), liabilities (η^B_t) and monetary policy (η^R_t).

The main contribution to the current account fluctuations comes from peripheral countries financial shocks, that account for 58.9% of the current account fluctuations over the time period. Thus, despite the increased contribution of common shocks, the current account fluctuations are more closely related to national financial developments: the need for cross-border lending in this fit exercise is not a substitute for common shocks.

We document in panel (c) of Figure 4.9 (page 141) the time path of the current account on a quarter-on-quarter basis by taking the point of view of peripheral countries (that has been characterized by a persistent current account deficit between 2001Q2 and 2007Q4). The solid line depicts the time path of the current account in deviation from the steady state as reported by the data, while bars depict the size of shocks in the corresponding deviation. As observed, the explanatory power of the model is quite high (the darker component in the figure that accounts for other factors not taken into account by the model has only a marginal contribution to the current account deficit) and we can link the time path of the peripheral countries' current account to shocks in a rather reliable way. Over the considered time period, the fluctuations in the current account are quite high (between -10% and +10%). As already noticed for the historical variance decomposition, the contribution of real shocks (originating from both the core and the periphery) is marginal. The contribution of core real and nominal developments is almost constant over the sample period and negatively contributes to the current account surplus. In contrast, peripheral real and nominal shocks that initially contributed to the deficit, have a positive (although marginal) contribution to the peripheral current account surplus after the occurrence of the financial crisis in the Eurozone.

Overall, financial shocks are the main drivers of the time path of the current account over the considered period. The deterioration of the current account between 2001Q2 and 2007Q4 is clearly linked to the jointly negative contribution of peripheral, core and common financial shocks, even if the former plays a key role in the reported time path. The transmission of the financial crisis in 2008 on the current account surplus appears as a combination of common and core countries' financial shocks. Leaving aside the first two quarters of 2009, the contribution of peripheral financial shocks remained negative long after the beginning of the financial crisis (at least up to the middle of 2011). They have a clear positive impact on the bilateral current account only since 2011Q3.

In Figure 4.9**,** we also document the time path of cross-border interbank loans on a quarter-on-quarter basis. In panel (a) we report the cross-border loans from core to peripheral countries while in panel (b) we present the time path of cross-border loans from peripheral to core countries. As observed, we get a better fit of the model for the latter phenomenon, especially after 2004Q1. Contrasting the two panels, our model clearly shows that financial innovations are the main drivers of cross border loans, as real and nominal factors contribute only marginally to the reported time path in both cases. Common financial factor affecting both regions of the Eurozone have had a positive impact on cross-border lending in both cross-border directions all over the time period. In particular they are the main driver of cross-border loans from peripheral countries. The financial situation of core countries leads to more cross-border loans towards the periphery (they affect positively the reported time path) while it affects negatively cross-border loans from the periphery. In contrast, financial shocks in the periphery contribute positively to cross-border lending from the core and negatively to the core. Putting pieces altogether clearly shows that peripheral countries have benefited form cross border lending over the sample time period: they received more loans than they exported, and this phenomenon has mainly been fuelled by peripheral financial shocks, as already been noted above for the time path of the bilateral current account.

7.3 Counterfactual Analysis

We report in Figure 4.10 the propagation of the financial crisis of 2009 on the model. We represent it as the sum of all the shocks that affected each economy in 2009Q1. In this figure, plain lines represent the adjustment of the corresponding variable estimated by the model, dotted lines report the IRFs computed with perfect banking integration and dashed lines report the IRFs computed without cross-border lending between the two regions of the Eurozone. We get two main findings from this counterfactual exercise: (i) peripheral countries have been much more affected by the crisis than core countries and (ii) the degree of cross-border banking affects the time path of the main national macroeconomic indicators (consumption being the main exception).

First, we find a deeper impact of the financial crisis on interbank loans (reported figures for the IRFs are almost twice the value of corporate loans for each part of the Eurozone). There is a sharp reduction in both corporate and interbank loans in the periphery while, in the core country group, the reduction of interbank loans 'only' diminishes by up to -10% (instead of -40% for the periphery) and the reduction in corporate loans reaches 'only' -3% (instead of -20% for the periphery). The persistency of the shock is also much higher on peripheral loans. Cross border banking has deteriorated the evolution of interbank lending in core countries while it has mildly improved the situation of interbank lending in the periphery. In contrast, the degree of cross-border banking estimated by the model between the two group of countries did not have a significant effect on the time path of corporate loans or on the cost of borrowing faced by firms.

Second, the size of the fluctuations in macroeconomic aggregates are in line with the behavior of financial variables, as the fluctuations in activity and investment are much more pronounced in the periphery than in the core countries. However, in both parts of the world, the time path of activity mimics that of investment. In the periphery, the financial crisis has clearly led to a sharper and more persistent decrease in investment (reaching a maximum decrease of -12% after 8 quarters instead of -2% after 5 quarters and going back to equilibrium after 11 periods for the core country group) and activity (reaching a maximum decrease of -1.5% after 8 quarters instead of -0.4% after 5 quarters and going back to equilibrium after 11 periods for the core country group). The contribution of cross border banking to the observed dynamics of output and investment underlines that cross-border lending has reduced the negative consequences of the financial crisis for core countries, with respect to a segmentation of the loan market, while it has mildly deteriorated the situation of the periphery.

As a final counterfactual exercise, we find that a perfect banking integration of the Eurozone (in dotted lines) would have amplified the fluctuations of all core countries' variables, while dampening that of peripheral countries. This complete integration would have led to a transfer of volatility between the two components of the Eurozone, contributing to a better mutualization of the negative consequences of the financial crisis over the region.

8 Conclusion

In this chapter, we have developed and estimated a two-country DSGE model with banking activity that accounts for interbank and corporate cross-border loan flows. Using Bayesian econometrics, we have found evidence of the key role of this cross-border channel as an amplifying mechanism in the diffusion of asymmetric shocks. In particular, our model reveals that under banking globalization, most national variables are less sensitive to national financial shocks while investment and current account imbalances are more affected. In a counterfactual analysis, we have analyzed how cross border lending has affected the transmission of the recent financial crisis between the two groups of countries.

Our model contributes to the New Open Economy Macroeconomics literature by finding two new channels of propagation of macroeconomic shocks between countries. Taken altogether, our results underline the critical contribution of corporate and interbank cross-border loans in the Eurozone to account for both the transmission of asymmetric shocks and the effect of monetary policy decisions. In particular, they suggest the importance of cross border loans to assess the impact of the financial accelerator in models of the Eurozone.

Looking forward, our analysis outlines several areas for future research. In particular, our model could be used as a framework to assess alternative way of supervising lending decisions (based on the home or host principle) and thus contribute to the current discussion of the best way of implementing macroprudential measures in the European Monetary Union.

Data sources

Gross domestic product: expenditure approach, millions of national currency, current prices, quarterly levels, seasonally adjusted - *sources Eurostat*. **Private final consumption expenditure:** millions of national currency, current prices, quarterly levels, seasonally adjusted - *sources Eurostat*. **Gross fixed capital formation:** millions of national currency, current prices, quarterly levels, seasonally adjusted - *sources Eurostat*. **HICP:** Overall Index excluding food and energy, Deseasonalized using a multiplicative decomposition - *sources ECB*. **Loans to Non-Financial corporations:** Index of Notional Stocks, Total maturity, Euro area (changing composition) counterpart, Deseasonalized using a multiplicative decomposition, monthly data (aggregated to get quarterly data) - *sources ECB (internal backcasted series)*. **Loans to MFIs:** Index of Notional Stocks, Total maturity, Euro area (changing composition) counterpart, Deseasonalized using a multiplicative decomposition, monthly data (aggregated to get quarterly data) - *sources ECB (internal backcasted series)*. **Borrowing cost:** monthly (taken in average to get quarterly data), Credit and other institutions (MFI except MMFs and central banks); Loans up to 1 year; BS counterpart sector: Non-Financial corporations (S.11); Outstanding amount - *sources ECB*. For 1999Q1-2003Q1, we approximated the series by using the interest rate on loans other than revolving loans and overdrafts, New business. **Official refinancing operation rates:** central bank interest rates, one year maturity, quarterly data - *sources Eurostat*. **Wages:** Labour cost index, nominal value - quarterly data (NACE Rev. 2), Seasonally adjusted and adjusted data by working days, Business economy, Wages and salaries (total) - *sources Eurostat*.

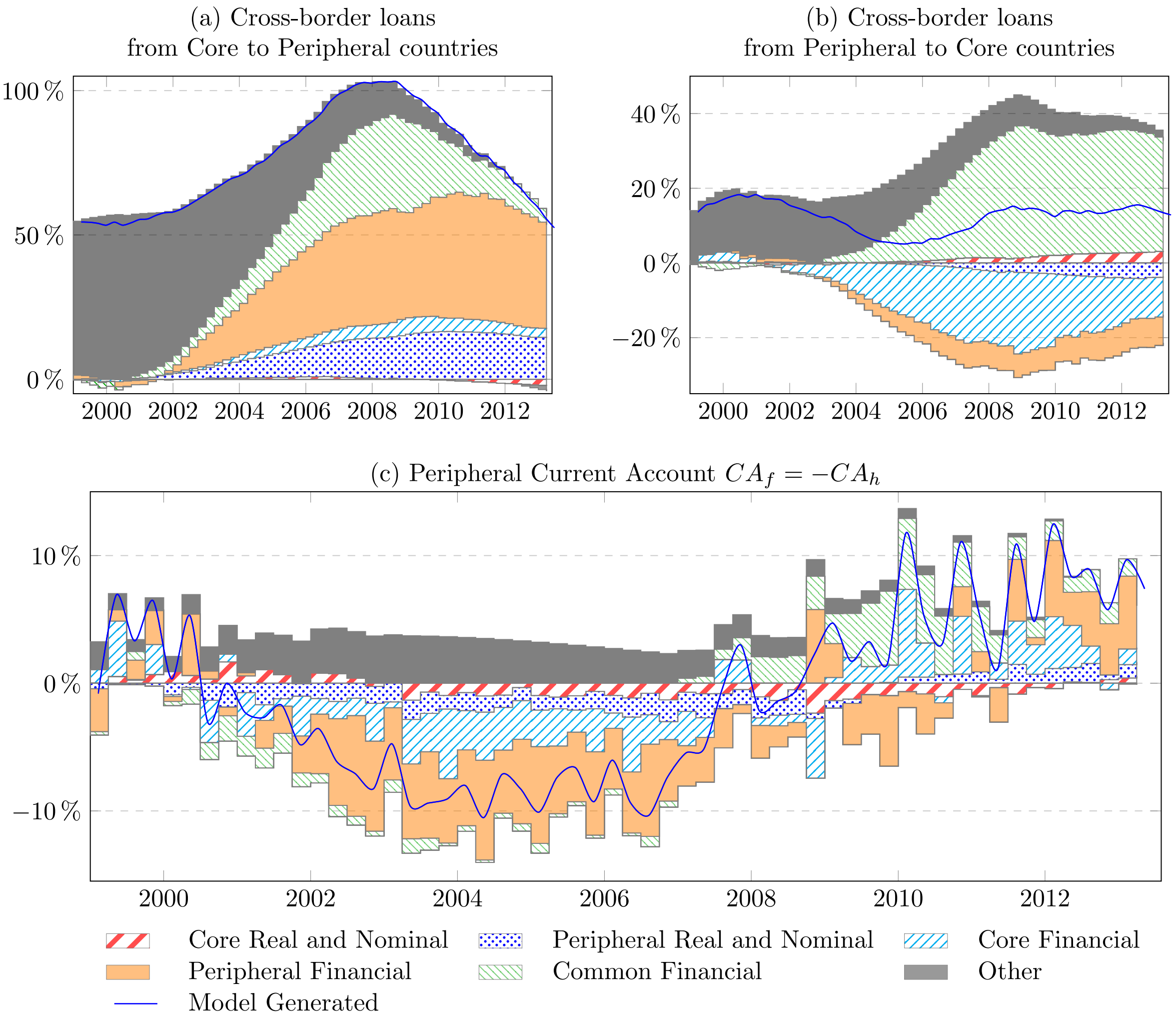


FIGURE 4.9: The peripheral current account (quarter-on-quarter % change generated by the model with cross-border flows).
Note: The solid blue line depicts the quarterly growth rate in real GDP and Investment (per capita), expressed in percentage point deviations from the model's steady state. The colored bars depict the estimated contributions of the various groups of shocks (Real and Nominal: productivity, wage cost-push, spending, preferences asymmetric shocks; Financial: external finance premium, credit cost push, net worth and liabilities asymmetric shocks; Common Financial: external finance premium, credit cost push, net worth, bank liabilities and monetary policy common shocks.

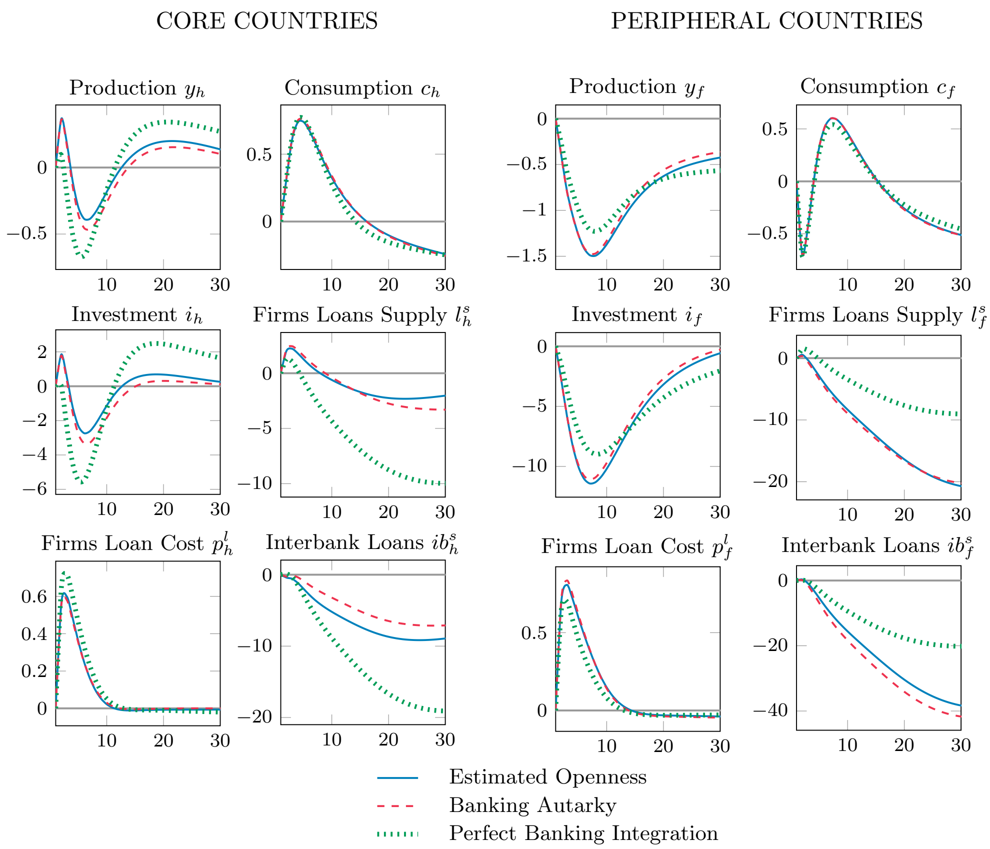


FIGURE 4.10: The system response during the financial crisis (2009Q1) under different levels of financial openness

Chapter 5

Combining National Macroprudential Measures with Cross-border Interbank Loans in a Monetary Union

1 Introduction

The recent financial crisis has led Eurozone countries to reform their supervisory framework. New institutions have been established following the report of De Larosière (2009). The new scheme is organized on two pillars: the first pillar is devoted to macro-prudential supervision comprising the European Systemic Risk Board (ESRB) and a second pillar devoted to micro-prudential supervision, comprising three different European Supervisory Authorities (ESAs) – one for banking, one for insurance and one for the securities markets.

The main objective of the ESRB is to promote a coordinated implementation of macro-prudential measures among the members of the Eurozone so as to provide a more robust macro-prudential supervisory framework. The organization of the European macroprudential scheme is original. First, it is the only supranational set-up yet to be observed[1].

[1]For a synthetic presentation of the various institutional situations observed in real life practices regarding the definition of the macroprudential mandate, see (Nier et al., 2011). In some cases, it involves a reconsideration of the institutional boundaries between central banks and financial regulatory agencies (or the creation of dedicated policymaking committees), while in other cases, efforts are made to favor the cooperation of authorities within the existing institutional structure. (Nier et al., 2011) find that the vast majority of arrangements that are in place or are being developed across countries can be organized in seven models, which in turn form three broad groups of models that differ in the degree of institutional integration between central bank and regulatory agencies.

Owing to their mutual financial integration, European countries have taken into account the fact that financial stability should be treated as a public good and that isolated national actions may undermine the conduct of an appropriate macroprudential policy. Second, it is the only macroeconomic policy in the Eurozone that accounts for country heterogeneities, as monetary policy reacts to Union wide aggregates while the Stability and Growth Pact (SGP) imposes common rules on national public debts and deficits.

The aim of this chapter is to evaluate how macroprudential instruments should be set in a monetary union such as the Eurozone, given this federal organization. We more particularly assess the degree of symmetry that should be promoted in the conduct of macroprudential policies. We develop a two-country DSGE model that accounts for some major features of the Eurozone regarding the problem at hands (key role of the banking system, cross-border bank loans, heterogeneity credit and business cycles) to provide a quantitative evaluation of welfare gains coming from the implementation of macroprudential measures. In this model, heterogeneity between the member countries of the Eurozone is accounted for by distinguishing core countries and peripheral countries[2].

We introduce three major features of the Eurozone in the analysis. First, we account for the key role of cross border loans in creating spillovers that lead to the diffusion of national macroprudential measures to other countries. In line with the data, we distinguish between interbank and corporate cross border loans. Second, we assume that, according to the indicative list of macroprudential instruments issued by the ESRB in 2013, national macroprudential authorities can use alternative instruments to affect either the lending or borrowing conditions of their country. We more particularly contrast the use of single vs multiple instruments in the conduct of macroprudential measures. Third, we consider a granular implementation of macroprudential policies designed to address the development of national financial imbalances.

The model, estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q3[3], leads to the following results: First we report a possible conflict between the federal and the national levels in the implementation of heterogeneous macroprudential measures based on a single instrument. On federal ground, the Pareto optimal situation requires an asymmetric choice of instruments. However, this is a no free lunch situation as it may create regional welfare losses. On regional grounds, more symmetric practices should be preferred to provide welfare gains to all the

[2] The criterion to divide the Eurozone in two blocks is discussed in the following section. Core countries: Austria, Belgium, Germany, Finland, France, Luxembourg and Netherlands. Peripheral countries: Spain, Greece, Ireland, Italy and Portugal.

[3] To our knowledge, the design of macroprudential measures has been approached by Darracq-Pariès et al. (2011), Quint & Rabanal (2013), Kannan et al. (2009), Benes & Kumhof (2011), Darracq-Pariès et al. (2011), Angelini et al. (2012), Bailliu et al. (2012), Beau et al. (2012), Collard et al. (2012), Rubio & Carrasco-Gallego (2012), Angeloni & Faia (2013), Brzoza-Brzezina et al. (2013), Lambertini et al. (2013), Medina & Roldós (2013), Suh (2014) and Kincaid & Watson (2013).

participating countries. Second, the adoption of combined instruments in each country solves this potential conflict as it leads to both a higher welfare increase in the Pareto optimal equilibrium and always incurs national welfare gains. Third, the Pareto optimal equilibrium cannot be reached on national incentives. Thus a supranational enforcing mechanism such as the one introduced by the ESRB is necessary independently of the nature and number of macroprudential instruments adopted in each country.

The chapter is organized as follows: Section 2 describes the institutional background and some stylized facts regarding the situation of the Eurozone. Section 3 outlines the model. Section 4 describes the estimation and the econometric results. Section 5 describes macroprudential instruments. Section 6 presents the welfare and macroeconomic consequences of alternative macroprudential regimes. Section 7 evaluates the sensitivity of the results with respect to cross border lending. Finally, Section 8 concludes.

2 The Institutional Background

This section sketches the main institutional aspects regarding the conduct of macroprudential policy in the Eurozone and briefly discusses the interest of adopting heterogeneous/homogenous macroprudential measures between participating countries.

2.1 The Federal Organization of Macroprudential Policy

At the federal level, the recent financial crisis revealed serious shortcomings in the conduct of financial supervision in the Eurozone as the growing integration of European financial markets and the increase in cross border banking that followed the adoption of the Euro has not been met by the adoption of similar legislations in the participating countries. In particular the implementation and enforcement of this legislation has ultimately been left to the discretion of Member States supervisors, according to the principle of home country control and mutual recognition.

The European Systemic Risk Board (ESRB) is aimed at providing tools to coordinate national macrorpudential policies. The ESRB cannot use macro-prudential instruments directly nor it has binding powers to impose the policy to nations belonging to this organization. Instead, it can issue warnings and recommendations to national authorities and to EU institutions[4]. Through the warnings or recommendations, the macro-prudential

[4]The ESRB has two instruments to carry out its mandate, namely warnings and recommendations. The difference between them is that warnings call for the attention of the addressees to identified systemic risks, without a detailed description of the actions required, whereas recommendations include advice on policy actions to be taken to mitigate the identified risks. Addressees of the ESRB's warnings and recommendations can be the European Union, individual EU Member States and the three ESAs, as well as national supervisory authorities in the EU. Recommendations may also be addressed to the European Commission in respect of the relevant EU legislation. Warnings and recommendations can either be confidential, and thus communicated only to the targeted addressees, or they can be public.

concerns of the ESRB should be transformed into action by other authorities or bodies. However, the recommendations are supported by an 'act or explain' mechanism where the addressees are obliged to provide a justification in case they do not follow the recommendations. If the ESRB considers that the reaction is inadequate, it should inform, subject to strict confidentiality rules, the addressees, the Council and, where appropriate, the European Supervisory Authority concerned.

As underlined by the ESRB (commentary 2) macro-prudential policy also has an important national component. First, because systemic risks can arise at the national (or sectoral) level, as financial cycles and the structural characteristics of financial systems typically differ between countries, and thus may require a different policy response. Second, because the responsibility for the adoption of the measures necessary to maintain financial stability lies within national frameworks. Therefore, the effectiveness of macro-prudential policy in Europe depends not only on the institutional structure at the EU level, but also on the institutional frameworks and policy mandates at the level of individual Member States.

The third ESRB recommendation deals with the macro-prudential mandate for national authorities and provides a set of guiding principles for the macro-prudential frameworks in the EU Member States. This authority should have sufficient powers to pursue macro-prudential policy and the necessary independence to fulfill its tasks. Recently the ESRB has proposed a classification of policy instruments according to their specific targets as well as possible selection of a more limited set of core instruments. (since April 2013, the ESRB has provided recommendations on an indicative list of macroprudential instruments)[5].

2.2 The granular implementation of macroprudential measures

The granular implementation of macroprudential measures in the Eurozone is original with respect to the conduct of both monetary and fiscal policies. In the later two cases, countries are treated uniformly. Monetary policy reacts to union wide aggregates, while national fiscal policy should respect ratios regarding deficit and debts uniformly set for all countries participating to the Eurozone.

As an original founding principle of the ESRB, macroprudential policy is tailored to the situation of countries to fit the heterogeneity of national financial cycles. This heterogeneity is underlined in Figure 5.1 by contrasting Eurozone core and peripheral countries according to their status in terms of surplus or deficit of their current account.

[5]In practice, Countries can set particular values for the different instruments. The rule is at follows: the national macro-prudential authorities in the EU should be able to tighten settings of instruments to levels above those provided for in EU legislation in a timely manner based on local conditions.

As reported main differences characterize financial developments in these two groups of countries. In particular, peripheral countries experienced an explosive growth of credit followed by a sharp drop as well as a rise of the corporate bond yield. These heterogeneous financial developments between core and peripheral countries may, in turn, require alternative macroprudential measures.

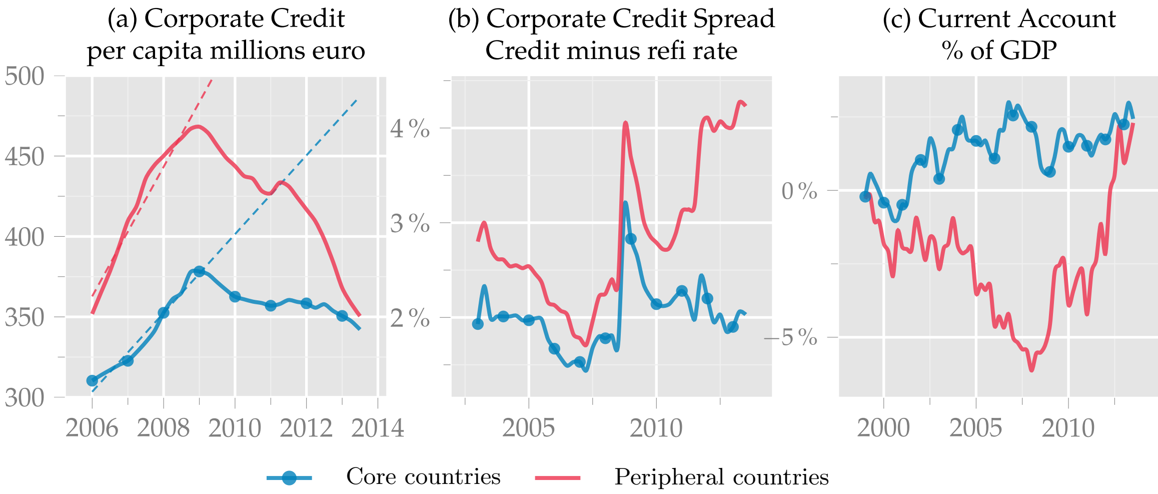


Figure 5.1: Regional divergences in the UEM

The problem faced by the ESRB is to accommodate these heterogeneous national financial development with more homogeneous national practices than encountered before the recent financial crisis. As shown in Figure 5.2, different policy initiatives have been taken since the creation of the ESRB, and a road map has been set to enhance more homogeneous practices among countries participating to this structure. As underlined by ESRB (2013, report October), this calendar can be analyzed as providing a smooth transition towards a more centralized and symmetric system.

The adoption of more homogeneous practices is a debated question. On one hand the interest of keeping heterogeneous macroprudential policy measures allows a granular treatment of financial risk in the Eurozone. As macro-prudential policies can be targeted at specific sectors or regional developments, they can help attenuate the credit cycle heterogeneity that characterizes the euro area and support a more balanced diffusion of monetary policy developments in the Eurozone.

On the other hand, the move towards more symmetric practices in the conduct of macroprudential practices can be justified on an economic ground as countries belonging to the Eurozone form an integrated financial area. In this area, banks provide the main liquidity to the system and cross-border banking has reached a value representing 24% of Eurozone GDP before the financial crisis of 2008. The transfer of macroprudential powers to the Federal level can thus make sense as cross-border banking activities have

The calendar

December 2011 : The ESRB recommends Member States to establish a legal mandate for national macro-prudential authorities by June 2013.

December 2012 : The Council agreed on a regulation creating a single supervisory mechanism (SSM) which will be responsible for the micro and macro-prudential supervision of all banks in the participating countries with the ECB acting as European supervisor "responsible for the effective and consistent functioning" of the mechanism.

April 2013 : The ESRB recommends Member States to ensure a minimum set of instruments is available, and identifies a common benchmark for intermediate objectives and instruments.

January 2014 : The new regulatory framework for banks enters into force (CRD4/CRR).

Summer 2014 : The SSM acquires some macro-prudential powers for instruments included in the CRD4/CRR, namely those related to banks.

December 2014 : Deadline ESRB recommendation on intermediate objectives and instruments.

December 2015 : Deadline ESRB recommendation on strategy.

Figure 5.2: Road map of the newly created institutions in the European Union

increased the interconnection of financial decisions in the Eurozone. Setting more homogenous macroprudential rules at the union level can be considered as a solution to a problem of externalities. Externalities arise from the fact that national authorities do not internalize their contribution to federal financial instability. Finally, the Single Supervisory Mechanism (SSM) initiative that promotes a uniform regulation of the banking system across the Eurozone may modify the original organization of macroprudential implementation for countries participating to this structure. As noted by shoemaker (2013) even if a centralized model should not imply a uniform application of the macroprudential tools across the countries in the SSM, in some instances, the European Central Bank may wish to apply a uniform macro-prudential requirement when a particular asset is increasing too fast in many SSM countries.

3 The Analytical Framework

This section introduces a two-country DSGE model that accounts for the main specificities of the Eurozone for the question at hands (namely financial heterogeneities and cross-border loans). Our framework[6] describes a monetary union made of two asymmetric areas $i \in \{c, p\}$ (where c is for core and p for periphery parts) of relative sizes n_c and n_p. As shown in Figure 5.4, each part of the monetary union is populated by consumers, intermediate and final producers, entrepreneurs, capital suppliers and a

[6]The whole model is presented in appendix.

Indicative list of macro-prudential instruments

1. **Mitigate and prevent excessive credit growth and leverage:**
   Counter-cyclical capital buffer
   Sectoral capital requirements (including intra-financial system)
   Macro-prudential leverage ratio
   Loan-to-value requirements (LTV)
   Loan-to-income/debt (service)-to-income requirements (LTI)

2. **Mitigate and prevent excessive maturity mismatch and market illiquidity:**
   Macro-prudential adjustment to liquidity ratio (e.g. liquidity coverage ratio)
   Macro-prudential restrictions on funding sources (e.g. net stable funding ratio)
   Macro-prudential unweighted limit to less stable funding (e.g. loan-to-deposit ratio)
   Margin and haircut requirements

3. **Limit direct and indirect exposure concentration:**
   Large exposure restrictions
   CCP clearing requirement

4. **Limit the systemic impact of misaligned incentives with a view to reducing moral hazard:**
   SIFI capital surcharges

5. **Strengthen the resilience of financial infrastructures:**
   Margin and haircut requirements on CCP clearing
   Increased disclosure
   Structural systemic risk buffer

FIGURE 5.3: Recommendation of the European Systemic Risk Board of 4 April 2013 on intermediate objectives and instruments of macro-prudential policy (ESRB/2013/1)

banking system. Regarding the conduct of macroeconomic policy, we assume national fiscal authorities and a common central bank. We present the model anticipating the symmetric equilibrium across households, firms and banks that populate the economy.

Households The representative household supplies $H_{i,t}$ hours of work, saves $D_{i,t}^{d}$ and maximizes utility intertemporally $\mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} e^{\varepsilon_{i,t+\tau}^{U}} \mathcal{U}\left(C_{i,t+\tau}, H_{i,t+\tau}\right)$, where $C_{i,t}$ is the consumption, $\beta \in (0,1)$ is the subjective discount factor and $\varepsilon_{i,t}^{U}$ is an exogenous shock to preferences. The period utility function takes the form $\mathcal{U}\left(C_{i,t}, H_{i,t}\right) \equiv \left(C_{i,t} - h_i^C C_{i,t-1}\right)^{1-\sigma^C} / \left(1-\sigma^C\right) - \chi_i H_{i,t}^{1+\sigma^L} / \left(1+\sigma^L\right)$ where $\sigma^L \geq 0$ is the curvature coefficient in the disutility of labor, $\sigma^C \geq 0$ is the risk aversion coefficient and $h_i^C \in [0,1)$ are external consumption habits. The consumption basket of the representative household is composed of home and foreign goods $C_{i,t} = ((1-\alpha_i^C)^{1/\mu} C_{hi,t}^{(\mu-1)/\mu} + (\alpha_i^C)^{1/\mu} C_{fi,t}^{(\mu-1)/\mu})^{\mu/(\mu-1)}$ where $1-\alpha_i^C > 1/2$ is the home bias in consumption and $\mu \geq 0$ is the elasticity of substitution between home and foreign goods.

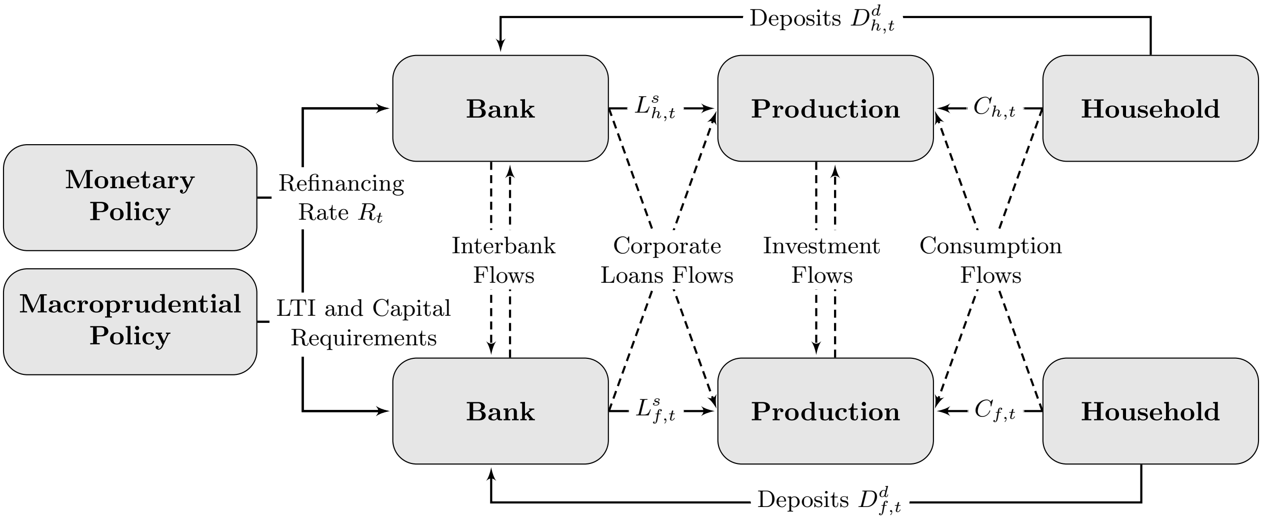


FIGURE 5.4: The model of a two-country monetary union with international bank loan flows

Firms There is a continuum of monopolistically competitive firms, each producing differentiated goods using hours of work and capital inputs $K_{i,t}$ and set production prices $P_{i,t}$ according to the Calvo model. Output supplied by firms is $Y_{i,t} = e^{\varepsilon^A_{i,t}} K^{\alpha}_{i,t} H^{1-\alpha}_{i,t}$ where $\varepsilon^A_{i,t}$ is an innovation to the productivity and $\alpha \in [0,1]$ is the share of capital services in the production. According to the Calvo mechanism, each period firms are not allowed to reoptimize the selling price with probability $\theta^P_i \in [0,1)$ but price increases of $\xi^P_i \in [0,1)$ at last period's rate of price inflation, $P_{i,t} = \pi^{\xi^P_i}_{i,t-1} P_{i,t-1}$ where $\pi_{i,t} = P_{i,t}/P_{i,t-1}$. Under this setting, it is possible to derive the aggregate inflation rate of production goods, it is defined by the function, $\pi_{i,t} = f\left(\mathbb{E}_t \pi_{i,t+1}, \pi_{i,t-1}, MC_{i,t}\right)$ where $MC_{i,t}$ is the marginal cost of production.

Entrepreneurs We add a financial constraint to the producing firms in order to implement a banking sector in the model. We standardly introduce an entrepreneurial sector that buys capital at price Q_t in t and uses that capital in the production in period $t+1$. Under this assumption, the capital arbitrage equation implies that the expected rate of return on capital is given by $1 + r^k_{i,t+1} = \mathbb{E}_t\left[Z_{i,t+1} + (1-\delta)\, Q_{i,t+1}\right]/Q_{i,t}$ where $\delta \in [0,1]$ and and $Z_{i,t}$ are respectively the depreciation rate and the marginal product of capital. Assuming that entrepreneurs are credit-constrained, they finance capital by their net wealth $N_{i,t}$ and lending $L^{\mathcal{H}}_{i,t+1}$ subject to external habits $h^L_i \in [0,1)$. The balance sheet of the entrepreneur then writes, $Q_{i,t} K_{i,t+1} = L^{\mathcal{H}}_{i,t+1} + N_{i,t+1}$. The entrepreneur has access to domestic and foreign banks to meet its balance sheet, $L_{i,t+1} = ((1-\alpha^L_i)^{1/\nu} L^{(\nu-1)/\nu}_{hi,t+1} + (\alpha^L_i)^{1/\nu} L^{(\nu-1)/\nu}_{fi,t+1})^{\nu/(\nu-1)}$ where α^L_i represents the percentage of cross-border loan flows in the monetary union. The total cost of loans, $P^L_{i,t}$, is thus defined according to, $\left(1+p^L_{i,t}\right)^{1-\nu} = ((1-\alpha^L_i)(1+r^L_{h,t})^{1-\nu} + \alpha^L_i(1+r^L_{f,t})^{1-\nu}$ where $r^L_{i,t}$ denotes the credit rate set by bank in country i.

The representative entrepreneur conducts a mass $\omega \in [\omega_{\min}, +\infty)$ of heterogenous investment projects drawn from Pareto distribution. The rentability of the ω^{th} investment project is, $\omega\left(1+r^k_{i,t+1}\right)$. There is a critical project $\omega^C_{i,t}$ that determines the threshold of profitability of the firm. Aggregating projects above the threshold, we can compute the share of profitable projects $\eta^E_{i,t}$ in the economy i. Supposing that entrepreneurs are optimistic as De Grauwe (2010) regarding their expected aggregated return ω on investment projects, we find the financial acceleration equation as in Bernanke et al. (1999). The external finance premium drives a wedge between the expected return on capital and the expected return demanded by banks and takes the form, $r^k_{i,t} - p^L_{i,t} \simeq \varkappa_i f\left(Q_{i,t}K_{i,t+1}/N_{i,t+1}\right)$ where $\varkappa_i > 0$ measures the elasticity of the premium with respect to leverage.

Banks In each country, the banking sector finances investment projects to home and foreign entrepreneurs by supplying one-period loans. The banking system is heterogenous with regard to liquidity, and banks engage in interbank lending at the national and international levels. To introduce an interbank market, we suppose that the banking system combines liquid and illiquid banks. Thus, cross-border loans are made of corporate loans (between banks and entrepreneurs) and interbank loans (between liquid and illiquid banks). We assume that banks distributed over $[0,\lambda]$ are illiquid *(i.e.* credit constrained), while the remaining banks distributed over share $[\lambda, n_i]$ are liquid and supply loans to entrepreneurs and to illiquid banks. We assume that a liquid bank is characterized by her direct accessibility to the ECB fundings. Conversely, an illiquid bank does not have access to the ECB fundings. According to this assumption, the balance sheet of the illiquid banks is $L^s_{i,t+1} = D_{i,t} + IB^{\mathcal{H}}_{i,t+1} + BK_{i,t+1} + E_{i,t}$ while the balance sheet of the liquid bank is $L^s_{i,t+1} + IB^s_{i,t+1} = D_{i,t} + L^{ECB}_{i,t+1} + BK_{i,t+1} + liab_{i,t}$, where $L^s_{i,t+1}(b)$ is the loan supply of borrowing banks, $D_{i,t}$ is the amount of households deposits, $IB^{\mathcal{H}}_{i,t+1}(b)$ is the interbank loans supplied by liquid banks subject to external habits at a degree $h^B_i \in [0,1)$, $IB^s_{i,t+1}$ is the supply of interbank loans, $BK_{i,t+1}$ is the bank capital, $liab_{i,t}$ are other liabilities in the balance sheet of the bank and $L^{ECB}_{i,t+1}$ is the amount of refinancing loans supplied by the central bank. The total amount borrowed by the representative bank writes, $IB^{(\xi-1)/\xi}_{i,t+1} = \left(1-\alpha^{IB}_i\right)^{1/\xi} IB^{(\xi-1)/\xi}_{hi,t+1} + \left(\alpha^{IB}_i\right)^{1/\xi} IB^{(\xi-1)/\xi}_{fi,t+1}$, where parameter $\xi \geq 0$ is the elasticity of substitution between domestic and foreign interbank funds, $\alpha^{IB}_i \in [0, 0.5]$ represents the percentage of cross-border interbank loan flows in the monetary union. The total cost incurred by illiquid banks to finance interbank loans, $p^{IB}_{i,t}$, is thus defined according to the CES aggregator, $\left(1+p^{IB}_{i,t}\right)^{1-\xi} = \left(1-\alpha^{IB}_i\right)\left(1+r^{IB}_{h,t}\right)^{1-\xi} + \alpha^{IB}_i\left(1+r^{IB}_{f,t}\right)^{1-\xi}$, where $r^{IB}_{h,t}$ (resp. $r^{IB}_{f,t}$) is the cost of loans obtained from home (resp. foreign) banks in country i. Following Hirakata et al. (2009), the bank capital accumulation process of illiquid banks ($BK_{i,t+1}$) is determined by, $BK_{i,t+1} = \left(1 - \tau^{BK}\right)\Pi^{B}_{i,t}$, where τ^{BK} is a proportional tax on the profits of the bank. Concerning macroprudential policy, we suppose that banks pay a capital requirement cost $F_i\left(\cdot\right)$ when their bank capital-to-assets ratio deviates from its steady state value. Regarding the interbank rate, the representative liquid bank decides the interbank rate by using a convex monitoring technology *à la* Cúrdia & Woodford (2010) denoted $AC^{IB}_{i,t+1}\left(b\right) = f\left(IB^{s}_{i,t+1}\right)$, in equilibrium the interbank rate is $r^{IB}_{i,t} = r_t + f'\left(IB^{s}_{i,t+1}\right)$. In the same vein as Darracq-Pariès et al. (2011), we measure the pass-through of interest rates by supposing that the representative bank sets the deposit and credit rates in staggered basis *à la* Calvo. Let θ^{L}_{i} (θ^{D}_{i}) denotes the country specific probability of the bank not being able to reset it credit (deposit) interest rate, the aggregate deposit rate writes, $r^{D}_{i,t} = f\left(\mathbb{E}_t r^{D}_{i,t+1}, r_t, \varepsilon^{D}_{i,t}\right)$ where $\varepsilon^{D}_{i,t}$ is a *ad hoc* markup shock and r_t is the (taylored) ECB refinancing rate. The New Keynesian Phillips Curve for deposit rates implies that the expected future rate depends on the refinancing rate markup and exogenous shock. Similarly, the aggregate credit rate is defined by, $r^{L}_{i,t} = f\left(\mathbb{E}_t r^{L}_{i,t+1}, \mathbb{E}_t\eta_{i,t+1}, r_t, p^{IB}_{i,t}, F^{L\prime}_{i,t}, \varepsilon^{L}_{i,t}\right)$. Solving forward $r^{L}_{i,t}$, one can see that current and expected future ECB rate r_t and firms default profitability $\mathbb{E}_t\eta_{i,t+1}$, interbank rate $p^{IB}_{i,t}$, Basel I capital requirement costs $F^{L\prime}_{i,t}$ and an *ad hoc* mark-up shock $\varepsilon^{L}_{i,t}$ drive today's credit rates.

Capital Suppliers The representative capital producer buys deprecated capital stock $\left(1-\delta\right)K_{i,t}$ and investment goods $I_{i,t}$ and produces new capital goods $K_{i,t+1}$ at a price $Q_{i,t}$. Capital supplier buys home and foreign investment goods, $I_{i,t} = (\left(1-\alpha^{I}_{i}\right)^{1/\mu} I^{(\mu-1)/\mu}_{hi,t} + \left(\alpha^{I}_{i}\right)^{1/\mu} I^{(\mu-1)/\mu}_{fi,t})^{\mu/(\mu-1)}$ where $1-\alpha^{I}_{i} > 0.5$ is the home bias in its consumption basket.

Monetary Policy Finally, monetary authorities choose the nominal interest rate according to a standard Taylor rule $1+r_t = f\left(\pi^{C}_{u,t}, \Delta Y_{u,t}, \varepsilon^{R}_{t}\right)$ where $\pi^{C}_{u,t}$ and $\Delta Y_{u,t}$ are the growth rates of price and GDP of the monetary union and ε^{R}_{t} is an exogenous monetary policy shock.

Shocks and Equilibrium Conditions In this model, there are 10 country specific structural shocks for each area $s = \{A, G, U, P, W, I, N, L, D, B\}$ and one common shock in the Taylor rule. The shocks follow a first order autoregressive process such that $\varepsilon^{s}_{i,t} = \rho^{s}_{i}\varepsilon^{s}_{i,t-1} + \eta^{s}_{i,t}$ and $\varepsilon^{R}_{t} = \rho^{R}\varepsilon^{R}_{t-1} + \eta^{R}_{t}$. In theses first-order autoregressive processes, ρ^{s}_{i} and ρ^{R} are autoregressive roots of the exogenous variables. Standard errors $\eta^{s}_{i,t}$ and η^{R}_{t} are mutually independent, serially uncorrelated and normally distributed with zero mean and variances $\sigma^{2}_{i,s}$ and σ^{2}_{R} respectively. A general equilibrium is defined as a sequence of quantities $\{\mathcal{Q}_t\}^{\infty}_{t=0}$ and prices $\{\mathcal{P}_t\}^{\infty}_{t=0}$ such that for a given sequence of quantities

$\{\mathcal{Q}_t\}_{t=0}^{\infty}$ and the realization of shocks $\{\mathcal{S}_t\}_{t=0}^{\infty}$, the sequence $\{\mathcal{P}_t\}_{t=0}^{\infty}$ guarantees the equilibrium on the capital, labor, loan, intermediate goods and final goods markets.

After (i) aggregating all agents and varieties in the economy, (ii) imposing market clearing for all markets, (iii) substituting the relevant demand functions, (iv) normalizing the total size of the monetary union $(n_c + n_p = 1)$ such that the size of the core area is n and the peripheral area size is $1 - n$, we can deduct the general equilibrium conditions of the model detailed in appendix.

4 Estimation and Empirical Performance

4.1 Data

The model is estimated with Bayesian methods on Euro Area quarterly data over the sample period 1999Q1 to 2013Q3. The dataset includes 17 time series: real GDP, real consumption, real investment, the ECB refinancing operation rate, the consumption deflator, the real unit labor cost index, the real index of notional stocks of corporate and interbank loans, and the real borrowing cost of non-financial corporations. Data with a trend are made stationary using a linear trend and are divided by the population. We also demean the data because we do not use the information contained in the observable mean. Figure 5.5 plots the transformed data.

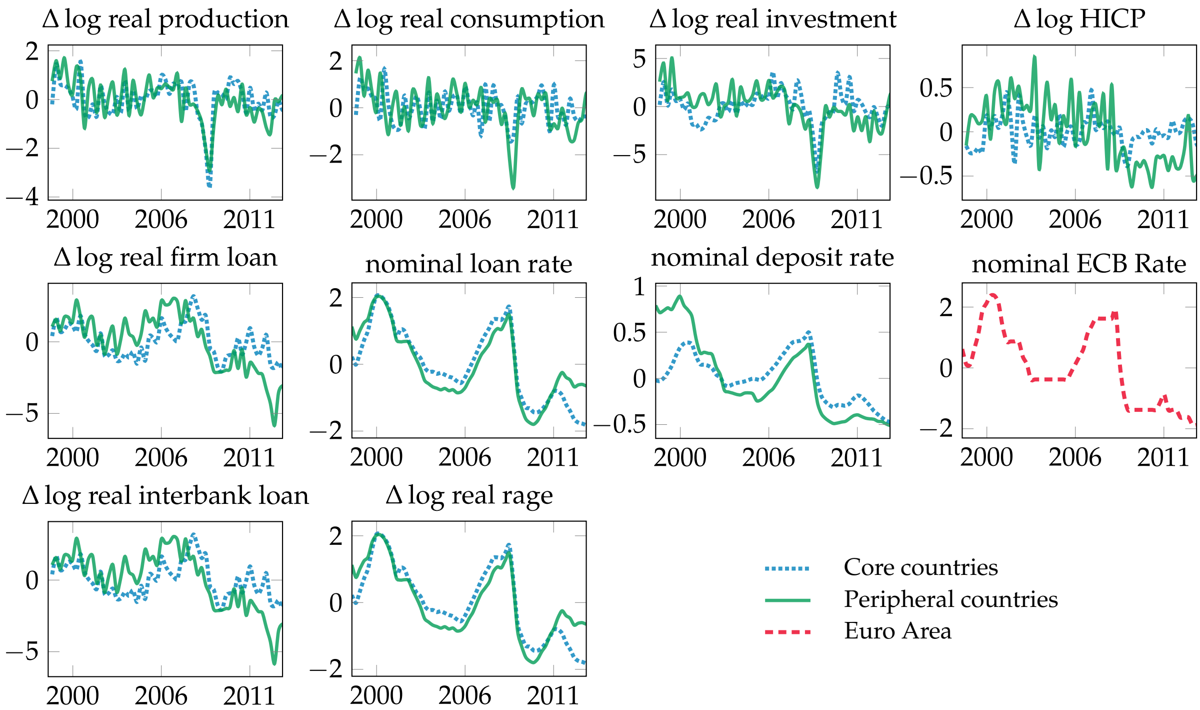


FIGURE 5.5: Observable variables

4.2 Calibration and Priors

The complete set of calibrated parameters is reported in Table 5.1. We fix a small number of parameters commonly used in the literature of real business cycles models[7]: these include β the discount factor, δ the quarterly depreciation rate, α the capital share in the production and the share of steady state hours worked $\bar{H}_i$. The government expenditures to GDP ratio is set at 24%[8]. Concerning the substitutability of good and wage varieties, it is calibrated as in Smets & Wouters (2007) at 10 which roughly implies a markup of 11%. Regarding financial parameters, we fix $\bar{N}/\bar{K}$ the net worth to capital ratio of entrepreneur near Gerali et al. (2010). The steady state value of spreads ($\bar{r} - \bar{r}^D$ and $\bar{r}^L - \bar{r}^D$) and the bank balance sheet ($\bar{D}/\bar{L}^s$, $\overline{BK}/\bar{A}$ and $\overline{IB}^d/\bar{A}$) are calibrated on their average values observed in the data. The steady state interbank rate is assumed to be equal to the ECB refinancing rate $\bar{r} = \bar{r}_c^{IB} = \bar{r}_p^{IB}$.The annual share of insolvent entrepreneurs' projects $\bar{\eta}^E$ is fixed at 2.5% and the quarterly cost of audit μ^B is 0.10, those values are comparable to Bernanke et al. (1999) and Hirakata et al. (2009). Following Kolasa (2009), we set the parameter governing the relative size of the core area n_c to 58%, which is the share implied by nominal GDP levels averaged over the period 1999-2013. The portfolio cost calibration χ^D is based on the findings of Schmitt-Grohé & Uribe (2003) and is deemed necessary to close open economy models. Finally, we find that parameters driving the substitutability between home and foreign loans are weakly identified due to their small impacts on the likelihood, thus we assume that loans are slightly substitutable such that $\nu, \zeta = 1.10$.

Our priors are listed in Table 5.3. Overall, they are either relatively uninformative or consistent with earlier contributions to Bayesian estimations. For a majority of new Keynesian models' parameters, *i.e.* σ^C, σ^L, h_i^C, θ_i^P, ξ_i^P, θ_i^W, ξ_i^W, ψ_i, χ_i^I, ϕ^π, $\phi^{\Delta y}$ and shocks processes parameters, we use the prior distributions close to Smets & Wouters (2003, 2007) and Kolasa (2009). All shocks process parameters are taken from Smets & Wouters (2007) except for the productivity shocks, we use priors similar to Smets & Wouters (2003)[9]. The Calvo probabilities are assumed to be around 0.75 for prices and wages as in Smets & Wouters (2003), while credit rates and deposit rates priors rely largely on Darracq-Pariès et al. (2011) with a mean of 0.50 and a standard deviation of 0.10. Concerning international macroeconomic parameters, our priors are inspired by Lubik & Schorfheide (2006). For the final goods market openness α_i^C and α_i^I, we choose

[7]The Euro area was created in 1999, so our sample is relatively short, following Smets & Wouters (2007), we calibrate rather than estimate structural parameters which are known to be weakly identified (we do not estimate parameters that determine the steady state of the model).

[8]On average, Euro Area households consumption represents 56% of the GDP and investment 20%, then the exogenous spending-GDP ratio is 24%.

[9]This prior on the productivity is necessary in the fit exercice to obtain a converging MCMC algorithm.

Parameter	Value	Description
β	0.995	Discount factor
δ	0.025	Depreciation rate
α	0.38	Capital share
$\bar{H}$	1/3	Steady state hours worked
$\varepsilon_p, \varepsilon_w$	10	Substitution between varieties
$\bar{r} - \bar{r}^D$	1.66/400	Refinancing rate minus the deposit rate
$\bar{r}^L - \bar{r}^D$	3.67/400	Credit rate minus the deposit rate
$\bar{G}/\bar{Y}$	0.24	Government expenditures to GDP ratio
$\bar{N}/\bar{K}$	0.40	Net worth to capital ratio
$\bar{D}/\bar{L}^s$	0.46	Deposit to loan ratio
$\overline{BK}/\bar{A}$	0.10	Bank capital to assets ratio
$\overline{IB}^d/\bar{A}$	0.20	Interbank loans demand to assets ratio
μ^B	0.10	Share of loss given default
$1 - \bar{\eta}^E$	2.50/400	Insolvency share of investment projects
n	0.58	Share of core countries in total EMU
ν, ζ	1.10	Substitutability of loans
χ^D	0.0007	Deposit adjustment cost

Table 5.1: Calibration of the model (all parameters are on a quarterly basis). Note: $\bar{A}$ term denotes the assets of the bank, it is $\bar{L}^s$ for illiquid banks and $\bar{IB}^s + \bar{L}^s$ for liquid ones.

priors in line with the findings of Eyquem & Poutineau (2010). The substitutability between different goods varieties is set at 1.50 with for standard deviation 0.50 which is inspired by Lubik & Schorfheide (2006). For the credit market openness, we choose priors coherent with the observed market openness over the period 1999-2013 and differ between Core and Periphery. The prior distribution mean of the corporate loan market openness is set at 4% for the core area and 8% for the Periphery. In the same vein, the interbank market openness is 20% and 25% for the Core and Periphery respectively. We set the prior for the elasticity of the external finance premium $\varkappa_i$ to a beta distribution with prior mean equal to 0.05 and standard deviation 0.03 consistent with previous financial accelerator estimations (Gilchrist, Ortiz, & Zakrajsek, 2009; Bailliu et al., 2012). In order to catch up the correlation and co-movement between countries' aggregates, we estimate the cross-country correlation between structural shocks. Our priors are inspired by in Jondeau et al. (2006) and Kolasa (2009), we set the mean of the prior distribution for the shock correlations between core countries and peripheral countries to 0.20 with a standard deviation of 0.20. For loan demand habits for firms and banks, we chose a very uninformative prior of mean 0.50 and standard deviation 0.15 with a beta distribution. We use a similar uninformative prior for the share of illiquid banks. The capital requirement cost χ_i^{KR} has a prior mean of 15 with standard deviation 2.50 which is between the assumption of Gerali et al. (2010) and Darracq-Pariès et al. (2011). Finally, the monitoring cost χ_i^B on the interbank market is set to a normal distribution with mean

0.05 and variance 0.02 with an inverse gamma distribution, which is consistent with Cúrdia & Woodford (2010).

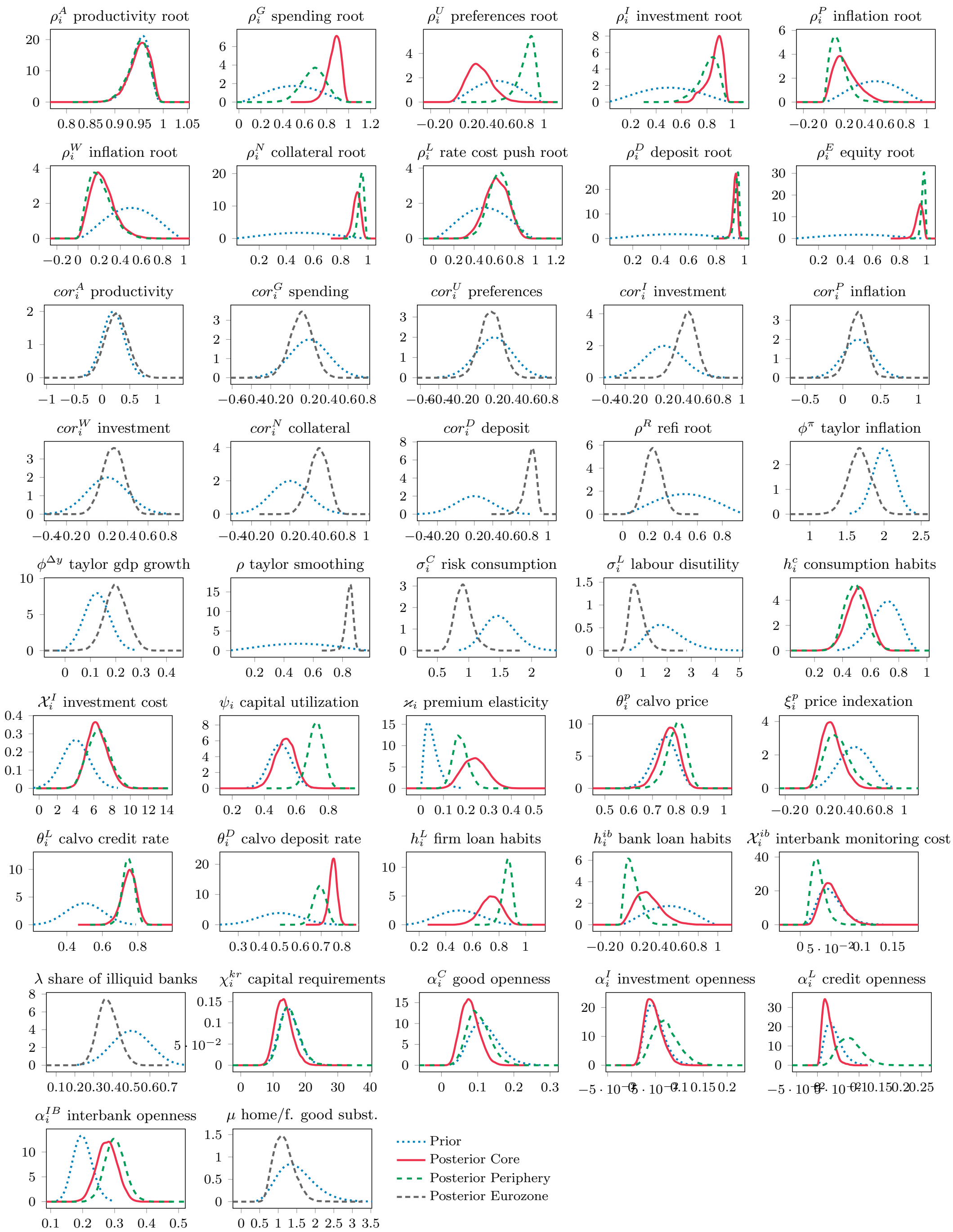


FIGURE 5.6: Prior and posterior distributions of parameters.

		Prior distributions			Posterior distribution *[5%:95%]*			
		Shape	Mean	Std.	CORE		PERIPHERY	
Standard Deviation								
Productivity	σ_i^A	$\mathcal{IG}$	0.40	0.50	0.31	*[0.14:0.47]*	0.26	*[0.12:0.41]*
Spending	σ_i^G	$\mathcal{IG}$	0.10	0.50	1.22	*[1.01:1.43]*	1.51	*[1.26:1.76]*
Preferences	σ_i^U	$\mathcal{IG}$	0.10	0.50	1.08	*[0.64:1.48]*	1.35	*[0.86:1.81]*
Investment cost	σ_i^I	$\mathcal{IG}$	0.10	0.50	3.48	*[1.92:5.02]*	3.44	*[2.09:4.80]*
Firms cost-push	σ_i^P	$\mathcal{IG}$	0.10	0.50	0.17	*[0.13:0.21]*	0.38	*[0.29:0.47]*
Wage cost-push	σ_i^W	$\mathcal{IG}$	0.10	0.50	0.51	*[0.41:0.62]*	0.72	*[0.58:0.86]*
Collateral crunch	σ_i^N	$\mathcal{IG}$	0.10	0.50	0.41	*[0.29:0.53]*	0.34	*[0.25:0.43]*
Deposit cost-push	σ_i^D	$\mathcal{IG}$	0.10	0.50	0.36	*[0.26:0.46]*	0.79	*[0.55:1.02]*
Bank liabilities	σ_i^E	$\mathcal{IG}$	0.10	0.50	5.12	*[4.20:6.01]*	8.86	*[7.29:9.35]*
Loans cost-push	σ_i^L	$\mathcal{IG}$	0.10	0.50	2.18	*[1.69:2.64]*	1.83	*[1.42:2.26]*
Monetary Policy	σ^R	$\mathcal{IG}$	0.10	0.50	0.08	*[0.07:0.10]*		
AR(1) Root								
Productivity	ρ_i^A	$\mathcal{B}$	0.95	0.02	0.95	*[0.92:0.98]*	0.95	*[0.91:0.98]*
Spending	ρ_i^G	$\mathcal{B}$	0.50	0.20	0.87	*[0.78:0.96]*	0.68	*[0.5:0.85]*
Preferences	ρ_i^U	$\mathcal{B}$	0.50	0.20	0.31	*[0.10:0.51]*	0.81	*[0.68:0.95]*
Investment cost	ρ_i^I	$\mathcal{B}$	0.50	0.20	0.86	*[0.76:0.95]*	0.81	*[0.69:0.93]*
Firms cost-push	ρ_i^N	$\mathcal{B}$	0.50	0.20	0.21	*[0.03:0.38]*	0.14	*[0.02:0.25]*
Wage cost-push	ρ_i^Q	$\mathcal{B}$	0.50	0.20	0.23	*[0.05:0.40]*	0.21	*[0.03:0.37]*
Collateral crunch	ρ_i^N	$\mathcal{B}$	0.50	0.20	0.92	*[0.87:0.96]*	0.95	*[0.92:0.98]*
Deposit cost-push	ρ_i^D	$\mathcal{B}$	0.50	0.20	0.93	*[0.91:0.96]*	0.94	*[0.92:0.97]*
Bank equity	ρ_i^E	$\mathcal{B}$	0.50	0.20	0.94	*[0.91:0.99]*	0.97	*[0.95:1.00]*
Loans cost-push	ρ_i^L	$\mathcal{B}$	0.50	0.20	0.62	*[0.44:0.80]*	0.64	*[0.47:0.81]*
Monetary policy	ρ_i^R	$\mathcal{B}$	0.50	0.20	0.24	*[0.13:0.35]*		
Correlation								
Productivity	cor_t^A	$\mathcal{N}$	0.20	0.20	0.25	*[-0.09:0.58]*		
Spending	cor_t^G	$\mathcal{N}$	0.20	0.20	0.11	*[-0.08:0.31]*		
Preferences	cor_t^U	$\mathcal{N}$	0.20	0.20	0.16	*[-0.04:0.35]*		
Investment cost	cor_t^I	$\mathcal{N}$	0.20	0.20	0.43	*[0.27:0.59]*		
Firms cost-push	cor_t^P	$\mathcal{N}$	0.20	0.20	0.19	*[0.00:0.38]*		
Wage cost-push	cor_t^W	$\mathcal{N}$	0.20	0.20	0.26	*[0.09:0.44]*		
Collateral crunch	cor_t^N	$\mathcal{N}$	0.20	0.20	0.50	*[0.34:0.66]*		
Deposit cost-push	cor_t^D	$\mathcal{N}$	0.20	0.20	0.81	*[0.71:0.90]*		
Bank equity	cor_t^E	$\mathcal{N}$	0.20	0.20	0.07	*[-0.12:0.26]*		
Loans cost-push	cor_t^L	$\mathcal{N}$	0.20	0.20	0.78	*[0.70:0.88]*		
Spending-productivity	cor_t^{ag}	$\mathcal{N}$	0.20	0.20	-0.03	*[-0.31:0.25]*	0.05	*[-0.28:0.40]*

Table 5.2: Prior and Posterior distributions of shock processes

4.3 Posteriors and Fit of the model

The methodology is standard to the Bayesian estimations of DSGE models[10]. Table 5.3 reports the prior and posterior distributions of the parameters of the model. Overall, all estimated structural parameters are significantly different from zero. Comparing our estimates of deep parameters with the baseline of Smets & Wouters (2003) for the Euro Area, we find higher standard deviations for most of the shocks, this mainly comes from the 2007 financial crisis captured by our model as strong demand shocks followed by persistent financial shocks. Concerning the parameters characterizing the investment adjustment cost, Calvo wage, consumption habits, labour disutility and the weight on output growth, our estimates are also very close to Smets & Wouters (2003). Turning to the degree of price stickiness, the monetary policy smoothing and the weight on inflation, our posterior distributions are close to the estimates of Christiano et al. (2010).

The main differences between core and peripheral countries explain the divergence of business cycles since the Eurozone creation. The gap between core and periphery originates from both shocks and structural parameters. Estimated standard deviation of real shocks are similar between the two areas, while nominal and financial shocks is larger in peripheral countries. The persistence of shocks is similar between countries except for the preference shock: households in peripheral countries experience large and volatile innovations. The disynchronization of the business cycles are also driven by the capital utilization cost elasticity, the external finance premium elasticity and the demand habits on the financial markets. The diffusion of monetary policy is not homogeneous and symmetric, particularly for the deposit market where the rate stickiness is more important in the peripheral area than in the core one.

Concerning the home bias in the consumption, investment, corporate loans and interbank loans baskets, the model's estimates are consistent with the data, suggesting that the peripheral countries import more than the core countries, implying current account deficits. The estimation of the credit markets openness is interesting, as underlined by

[10]Interest rates data are annualized, we take into account this maturity by multiplying by 4 the rates in the measurement equation. The number of shocks and observable variables are the same to avoid stochastic singularity issue. Recalling that $i \in \{c, p\}$, the vectors of observables $\mathcal{Y}_t^{obs} = [\Delta \log \hat{Y}_{i,t}, \Delta \log \hat{C}_{i,t}, \Delta \log \hat{I}_{i,t}, r_t, \pi_{i,t}^c, \Delta \log \hat{L}_{i,t}^s, r_{i,t}^L, r_{i,t}^D, \Delta \log \widehat{IB}_{i,t}^s]'$ and measurement equations $\mathcal{Y}_t = [\hat{y}_{i,t} - \hat{y}_{i,t-1},\ \hat{c}_{i,t} - \hat{c}_{i,t-1},\ \hat{\imath}_{i,t} - \hat{\imath}_{i,t-1},\ 4\hat{r}_t,\ \hat{\pi}_{i,t}^c,\ \hat{l}_{i,t}^s - \hat{l}_{i,t-1}^s,\ 4\hat{r}_{i,t}^L,\ 4\hat{r}_{i,t}^D, \widehat{ib}_{i,t}^s - \widehat{ib}_{i,t-1}^s]'$, where Δ denotes the temporal difference operator, $\hat{X}_t$ is per capita variable of X_t and $\hat{x}_t$ is the loglinearized version of X_t. The model matches the data setting $\mathcal{Y}_t^{obs} = \overline{\mathcal{Y}} + \mathcal{Y}_t$ where $\overline{\mathcal{Y}}$ is the vector of the mean parameters, we suppose this is a vector of all 0. The posterior distribution combines the likelihood function with prior information. To calculate the posterior distribution to evaluate the marginal likelihood of the model, the Metropolis-Hastings algorithm is employed. We compute the posterior moments of the parameters using a sufficiently large number of draws, having made sure that the MCMC algorithm converged. To do this, a sample of 150,000 draws was generated, neglecting the first 50,000. The scale factor was set in order to deliver acceptance rates of between 20 and 30 percent. Convergence was assessed by means of the multivariate convergence statistics taken from Brooks & Gelman (1998).

		Prior distributions			Posterior distribution [5%:95%]			
		Shape	Mean	Std.	CORE		PERIPHERY	
Consumption aversion	σ^C	$\mathcal{G}$	1.50	0.25		0.92	[0.69:1.13]	
Labour disutility	σ^L	$\mathcal{G}$	2.00	0.75		0.76	[0.29:1.21]	
Consumption inertia	h_i^C	$\mathcal{B}$	0.70	0.10	0.51	[0.38:0.64]	0.49	[0.36:0.61]
Calvo prices	θ_i^P	$\mathcal{B}$	0.75	0.05	0.77	[0.7:0.84]	0.80	[0.74:0.87]
Indexation prices	ξ_i^P	$\mathcal{B}$	0.50	0.15	0.27	[0.1:0.43]	0.33	[0.13:0.53]
Calvo wage	θ_i^W	$\mathcal{B}$	0.75	0.05	0.84	[0.79:0.89]	0.86	[0.81:0.91]
Indexation wage	ξ_i^W	$\mathcal{B}$	0.50	0.15	0.37	[0.21:0.53]	0.26	[0.12:0.39]
Calvo loan rates	θ_i^L	$\mathcal{B}$	0.50	0.10	0.75	[0.68:0.82]	0.75	[0.69:0.8]
Calvo deposit rates	θ_i^D	$\mathcal{B}$	0.50	0.10	0.76	[0.73:0.79]	0.69	[0.64:0.74]
Investment cost	χ_i^I	$\mathcal{N}$	4.00	1.50	6.37	[4.58:8.23]	6.53	[4.39:8.4]
Capital utilization	ψ_i	$\mathcal{N}$	0.50	0.07	0.53	[0.43:0.63]	0.72	[0.64:0.8]
Premium elasticity	$\varkappa_i$	$\mathcal{N}$	0.05	0.03	0.24	[0.15:0.32]	0.17	[0.12:0.23]
Loan demand habits	h_i^L	$\mathcal{B}$	0.50	0.15	0.74	[0.62:0.87]	0.86	[0.8:0.92]
Share of illiquid banks	λ	$\mathcal{B}$	0.50	0.10		0.38	[0.29:0.46]	
Interbank demand habits	h_i^B	$\mathcal{B}$	0.50	0.15	0.29	[0.07:0.48]	0.13	[0.02:0.23]
Interbank monitoring cost	χ_i^B	$\mathcal{G}$	0.05	0.02	0.05	[0.02:0.08]	0.03	[0.01:0.05]
Capital requirements	χ_i^{KR}	$\mathcal{G}$	15	3.00	13.3	[9.14:17.37]	15.22	[10.48:20.13]
Goods openness	α_i^C	$\mathcal{B}$	0.12	0.04	0.08	[0.04:0.12]	0.1	[0.05:0.15]
Investment openness	α_i^I	$\mathcal{B}$	0.12	0.04	0.05	[0.02:0.07]	0.07	[0.03:0.11]
Corporate openness	α_i^L	$\mathcal{B}$	0.04/0.08	0.03	0.03	[0.01:0.04]	0.08	[0.03:0.12]
Interbank openness	α_i^{IB}	$\mathcal{B}$	0.20/0.25	0.03	0.28	[0.22:0.33]	0.30	[0.25:0.35]
Goods substitution	μ	$\mathcal{G}$	1.50	0.50		1.16	[0.73:1.59]	
MPR smoothing	ρ	$\mathcal{B}$	0.50	0.20		0.85	[0.81:0.88]	
MPR inflation	ϕ^π	$\mathcal{N}$	2.00	0.15		1.67	[1.42:1.93]	
MPR GDP	$\phi^{\Delta y}$	$\mathcal{N}$	0.125	0.05		0.20	[0.13:0.27]	
Marginal log-likelihood							-1004.2	

TABLE 5.3: Prior and Posterior distributions of structural parameters and shock processes. Note: $\mathcal{IG}$ denotes the Inverse Gamma distribution, $\mathcal{B}$ the Beta, $\mathcal{N}$ the Normal, $\mathcal{G}$ the Gamma.

Brunnermeier et al. (2012), cross-border banking within the euro area experienced explosive growth, especially after around 2003, helping to fuel property booms in Ireland and southern European countries. The model captures this feature as the degrees of openness of the credit market in peripheral countries is larger than in core countries.

To assess how well the model fits the data, we present in Table 5.4 and in Figure 5.7 the second moments of the observable variables and their counterpart in the model. The model does reasonably well in explaining the standard deviation of most of the variables except for some of the financial variables, despite allowing for different degrees of nominal rigidities via the introduction of Calvo contracts and habits. Nevertheless, the model captures well the persistence of all aggregates except for inflation in the core area. Concerning the cross-country correlations, the model does reasonably well in capturing the co-movement of all aggregates, however the model underestimates the cross-country correlation between home and foreign output and investment.

	2nd Moments - Standard Deviation								
	$\Delta Y_{i,t}$	$\Delta C_{i,t}$	$\Delta I_{i,t}$	$\pi^c_{i,t}$	$\Delta W^r_{i,t}$	$\Delta L^s_{i,t}$	$r^L_{i,t}$	$r^D_{i,t}$	$\Delta IB^s_{i,t}$
Empirical - Home	0.80	0.67	1.68	0.18	0.48	1.22	1.12	0.27	2.76
Theoretical - Home	*0.86*	*0.69*	*2.61*	*0.24*	*0.52*	*1.15*	*1.51*	*0.60*	*5.88*
Empirical - Foreign	0.86	0.93	2.25	0.38	0.72	2.05	1.05	0.44	3.87
Theoretical - Foreign	*0.95*	*0.91*	*2.87*	*0.41*	*0.74*	*1.73*	*1.08*	*0.74*	*7.80*

Table 5.4: Empirical and Theoretical Standard deviations

5 Macroprudential Policy

As reported by Lim (2011), a number of instruments may be effective in addressing systemic risks in the financial sector. In this chapter, we take into account the classification initially introduced by Blanchard et al. (2013). We assume that macroprudential policy is implemented through two instruments: one directed towards the financial stability of the lender, the other towards the borrower.

5.1 Countercyclical Capital Buffers

First regarding lenders, we assume that macroprudential policy accounts for a ratio related to the Basel *I*-like capital requirement of the banking system augmented with

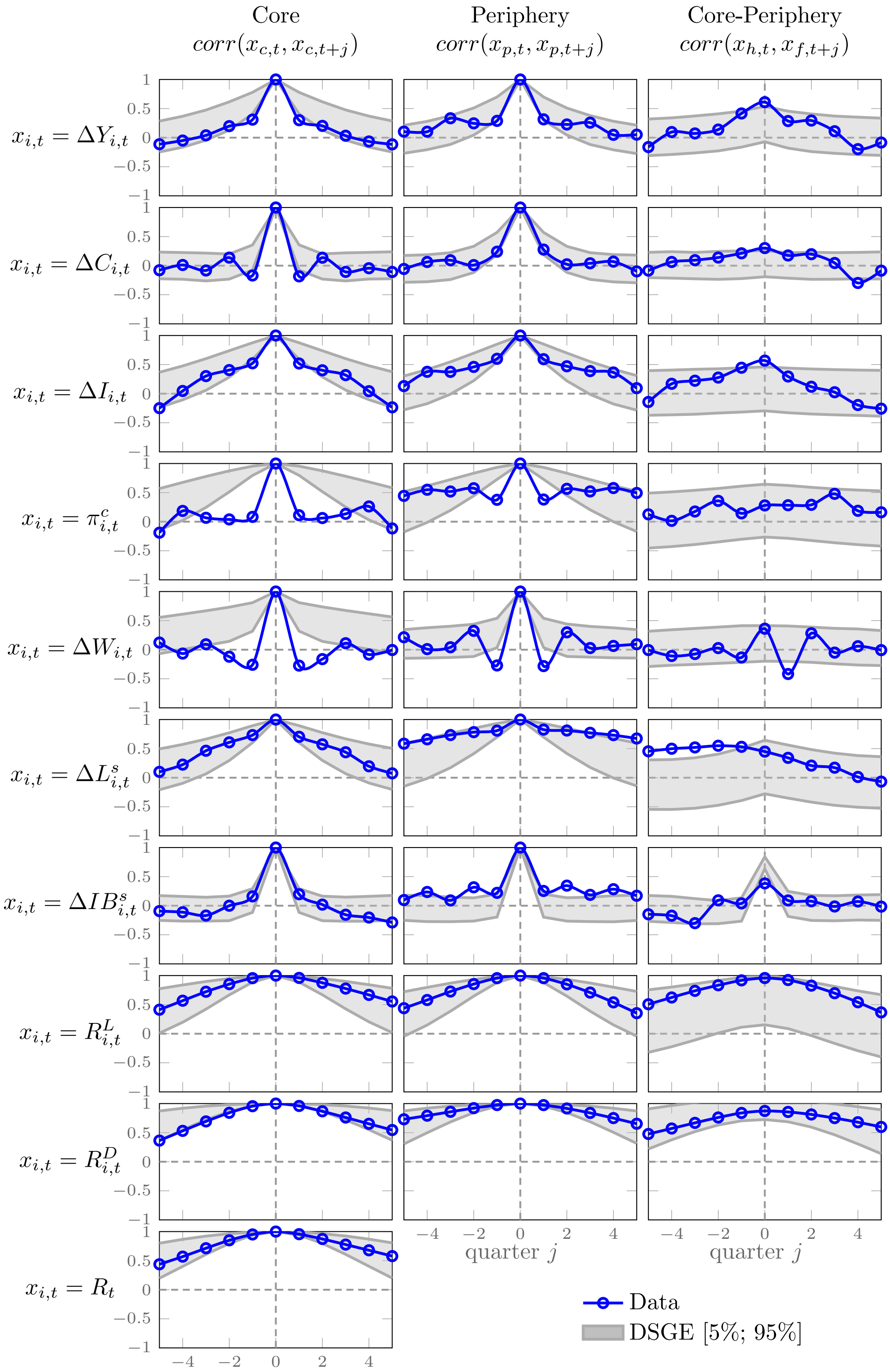


FIGURE 5.7: Dynamic correlations of the main variables: observable variables (blue) and 90% confidence band interval generated by the estimated model centered around the asymptotic mean

counter-cyclical capital buffers (Darracq-Pariès et al., 2011):

$$F_i\left(\frac{BK_{i,t+1}}{A^{rw}_{i,t+1}}, ccb_{i,t}\right) = 0.5\chi_i^{KR}\left(\frac{BK_{i,t+1}}{A^{rw}_{i,t+1}} - ccb_{i,t}\right)^2, \tag{5.1}$$

where $F(\cdot)$ implies that the bank must pay a quadratic cost whenever the bank capital to risk weighted assets ratio $BK_{i,t+1}/A^{rw}_{i,t+1}$ moves away from a time-varying optimal target $ccb_{i,t}$[11]. Since Basel III uses the gap between the credit-to-GDP ratio and its long-term trend as a guide for setting countercyclical capital buffers[12], we introduce time-varying capital requirements with a target bank capital ratio implemented in country i that follows a rule of the form:

$$ccb_{i,t} = \left(\frac{ctg_{u,t}}{\overline{ctg}_u}\right)^{\phi_i^{CCB}}, \tag{5.2}$$

where $ctg_{u,t}$ is the credit-to-GDP ratio of the monetary union $ctg_{u,t} = (ctg_{h,t})^n (ctg_{f,t})^{1-n}$ with $ctg_{i,t} = \left(L^s_{i,t} + IB^s_{i,t}\right)/Y_{i,t}$ and ϕ_i^{CCB} denotes the reaction degree of countercyclical capital buffers to a deviation from the long term credit-to-GDP ratio of the monetary union. Under this setting, the borrower oriented instrument is based on a common objective (the credit to GDP) but allows for some heterogeneity in the way capital buffers are released, such that $\phi_c^{ccb} \neq \phi_p^{ccb}$.

5.2 Loan-to-Income Ratio

Second, regarding borrowers, we assume that macroprudential policy accounts for the evolution of the loan-to-income ratio of firms (Gelain et al., 2012). The rule of loan-to-income is defined by:

$$LTI_{i,t} = \left(\frac{L^d_{i,t+1}/Y_{i,t}}{L^d_i/Y_i}\right)^{\phi_i^{LTI}}, \tag{5.3}$$

where $L^d_{i,t+1}$ denotes the lending demand from the home private sector and $Y_{i,t}$ is the output. Thus when $LTI_{i,t}$ increases, it is interpreted by macroprudential authorities as an excessive growth to credit in comparison to activity.

As noticed, in these two expressions (5.1) and (5.3), the value of loans that is taken into account differs in the two instruments, given the possibility of national banks to engage

[11] According to the Basel I accords, the banks assets are weighted according to their risk. Letting γ^L_{rw} and γ^{IB}_{rw} denote the risk weighting of the Basel I regulatory framework, the risk-weighted assets for illiquid banks are defined by $A^{rw}_{i,t+1} = \gamma^L_{rw}L^s_{i,t} + \left(1-\gamma^L_{rw}\right)\bar{L}^s_i$, while for liquid banks it is determined by $A^{rw}_{i,t+1} = \gamma^L_{rw}L^s_{i,t} + \left(1-\gamma^L_{rw}\right)\bar{L}^s_i + \gamma^{IB}_{rw}IB^s_{i,t} + \left(1-\gamma^{IB}_{rw}\right)\overline{IB}^s_i$. Following the Basel accords (2004), interbank loans are given a (fixed) risk weight of 20 percent ($\gamma^{IB}_{rw} = 0.20$), whereas the risk weight attached to corporate loans is 100 percent ($\gamma^L_{rw} = 1$).

[12] See Drehmann & Tsatsaronis (2014) for further discussions about the credit to GDP ratio as the drivers of countercyclical buffers.

in cross-border lending and in the interbank market. Thus, the instrument directed toward the lending side of the economy accounts for the supply of loans in the country, while the instrument directed towards the borrowing side accounts for the fact that national agents can borrow from different national sources. However, neglecting the possibility for banks to engage in cross-border activities would make both instruments substitutable in the evaluation of systemic risk at the national level.

In this set-up, macroprudential instruments affect the general equilibrium of the model through the lending conditions of commercial banks. A tightening of credit conditions due to macroprudential measures will thus increase the interest rate faced by borrowers. In the presence of macroprudential regulations, the corporate loan marginal cost of liquid banks is affected by the macroprudential policy,

$$1 + MC_{i,t}^{ill} = \left[\left(1 + p_{i,t}^{IB}\right) + F_{i,t}^{L\prime} BK_{i,t+1}^{ill} \right] \frac{LTI_{i,t}}{1 - \mu^B \eta_{i,t}},$$

as well as the corporate loan marginal cost of liquid banks:

$$1 + MC_{i,t}^{liq} = \left[(1 + r_t) + F_{i,t}^{L\prime} BK_{i,t+1}^{liq} \right] \frac{LTI_{i,t}}{1 - \mu^B \eta_{i,t}},$$

and the interbank rate are affected by macroprudential policy:

$$1 + r_{i,t}^{IB} = (1 + r_t) + AC_{i,t}^{IB\prime} + F_{i,t}^{IB\prime} BK_{i,t+1}^{liq},$$

where F_L' and F_{IB}' denote the derivative of $F(\cdot)$ in $L_{i,t}^s$ and $IB_{i,t}^s$.

6 The setting of instruments

This section discusses how macroprudential policy should be conducted in the monetary union when taking into account the possibility for countries to adopt heterogeneous practices. We successively consider the consequences of choosing symmetric/asymmetric individual instruments and the consequences of implementing the macroprudential policy using multiple instruments at the regional level. We report in four different tables (Table 5.5, Table 5.6, Table 5.8 and Table 5.9) the households unconditional consumption gains or losses from leaving the benchmark situation where the European Central Bank implements an optimal monetary policy rule.

In the quantitative simulation, we first search for weights attached to inflation ϕ^{π} and GDP growth $\phi^{\Delta y}$ in the Taylor rule that gives the highest unconditional welfare of households. Here, we maintain the autoregressive parameter of the policy rule ρ^R at its estimated value since it has low effects on welfare. Based on the grid search by 0.01 unit, we limit our attention to policy coefficients in the interval $(1, 3]$ for ϕ^{π}, $[0, 3]$ for $\phi^{\Delta y}$

as Schmitt-Grohé & Uribe (2007), and in the interval $[0, 10]$ for macroprudential instruments ϕ_i^{CCB} and ϕ_i^{LTI}. Our grid search interval for macroprudential instruments is consistent with the findings of Gerali et al. (2010). The size of this interval is arbitrary. However, we assume that policy coefficients larger than 10 would be difficult to communicate to policymakers or the public (this assumption is in line with Schmitt-Grohé & Uribe (2007)).

6.1 Setting individual instruments

The indicative list of macroprudential instruments selected by the ESRB provides the member countries with a wide selection of macroprudential measures tailored to address its financial problems. In this subsection, we concentrate on the implementation of single instrument macroprudential policy measures at the regional level.

We report in Table 5.5 four possibilities of combining macroprudential instruments depending on the adoption of either a lender or a borrower instrument in each part of the Eurozone. Payoffs are defined in terms of permanent consumption gains. In all cases the implementation of macroprudential policy leads to welfare gains at the federal level. However, the macroprudential stance in each region (the values of $\phi_i^{CCB}$and φ_i^{LTI}) depends on the instrument adopted in the other part of the monetary union and may imply a regional decrease in welfare with respect to the benchmark situation.

First, the degree of symmetry in the choice of instruments affects national outcomes. Symmetric practices (in regimes (a) and (b)) lead to welfare gains in both parts of the monetary union, while the asymmetric choices of instruments in regimes (b) and (c) leads to welfare losses in the region implementing macroprudential policy using the a lender instrument. In contrast, the region adopting the borrower instruments records very high permanent consumption gains.

Second, leaving member countries choosing the macroprudential instrument (i.e., computing the Nash equilibrium) we find that regions are naturally encouraged to select regime (d) as the equilibrium. In this situation, they adopt symmetrical borrower instruments, as both countries experience welfare gains. However, on federal ground this situation is not optimal, as the average union wide permanent consumption increase ($\mathcal{W}_u = 0.382\%$) is much lower than the one encountered in regime (b) ($\mathcal{W}_u = 0.785\%$).

Third, the optimal federal situation reached in (b) requires an asymmetric choice of instruments between regions of the Eurozone: the periphery should select a borrower instrument, while the core should select a lender instrument. This makes sense regarding to the fact that peripheral countries are net importers of loans in the Eurozone. However, while the average union welfare increase represents $\mathcal{W}_u = 0.785$ % of permanent consumption, it leads to high inequalities between regions: the periphery is a net winner (with a permanent consumption increase of $\mathcal{W}_p = 3.443$ %), while welfare decreases in the core (with a permanent consumption decrease of $\mathcal{W}_c = -2.061$ %). This optimal equilibrium is thus difficult to implement, as the core may disagree to participate to the macroprudential scheme with the peripheral countries.

Fourth, another equilibrium should be considered, combining the highest possible federal permanent consumption increase subject to positive welfare gains in both regions. Under this simple criterion, the best possible outcome is regime (a), *i.e.*, the adoption of symmetric macroprudential measures using lender instruments. In this situation the increase of welfare represents $\mathcal{W}_c = 0.301\%$ of permanent consumption in the core countries, $\mathcal{W}_p = 1.006\%$ of permanent consumption in the core countries, leading to an average increase of permanent consumption of $\mathcal{W}_u = 0.599\%$ in the Eurozone. However, to be enforceable this equilibrium requires a supranational coordination mechanism such as the ESRB. This situation is more interesting than the Nash equilibrium (d), for peripheral countries and less interesting for core countries.

6.2 Combining multiple instruments

The previous subsection has outlined the federal optimality of macroprudential policy using asymmetric instruments. However, symmetric practices should be preferred on national grounds, as they lead to permanent consumption increases in both parts of the Eurozone. A simple way to reconcile these two sets of results is to combine both instruments in each region of the Eurozone. The use of multiple instruments at the regional level may be helpful to address the various natures of financial imbalances, while the symmetric implementation of macroprudential instruments among the members of the monetary union increases both region welfare. This approach is in line with Lim (2011) that report many country experiences based on a combination of several instruments while the use of a single instrument to address systemic risk is rare. The rationale for using multiple instruments is to provide a greater assurance of effectiveness by tackling a risk from various angles.

		PERIPHERY	
		Lender Tool $\phi_p^{CCB} \geq 0$	*Borrower Tool* $\varphi_p^{LTI} \geq 0$
CORE	*Lender Tool* $\phi_c^{CCB} \geq 0$	$\mathcal{W}_c = 0.301,\ \mathcal{W}_p = 1.006$ $\mathcal{W}_u = 0.599$ $\phi_c^{CCB} = 7.78,\ \phi_p^{CCB} = 5.42$ (a)	$\mathcal{W}_c = -0.197,\ \mathcal{W}_p = 2.111$ $\mathcal{W}_u = 0.785$ $\phi_c^{CCB} = 9.22,\ \varphi_p^{LTI} = 0.02$ (b)
	Borrower Tool $\varphi_c^{LTI} \geq 0$	$\mathcal{W}_c = 1.64,\ \mathcal{W}_p = -1.919$ $\mathcal{W}_u = 0.156$ $\varphi_c^{LTI} = 0.02,\ \varphi_p^{CCB} = 6.76$ (c)	$\mathcal{W}_c = 0.568,\ \mathcal{W}_p = 0.126$ $\mathcal{W}_u = 0.382$ $\varphi_c^{LTI} = 0,\ \varphi_p^{LTI} = 0.04$ (d)

Table 5.5: Homogenous/heterogenous practices in the conduct of Macroprudential Policy between different areas in the Euro Area: Nash equilibrium payoffs matrix in terms of unconditional consumption gains from leaving the standard optimal monetary policy.

		PERIPHERY	
		Coordination $\phi_p^{CCB} = 2.52, \varphi_p^{LTI} = 0.03$	*No Coordination* $\phi_p^{CCB} = 0, \varphi_p^{LTI} = 0.01$
CORE	*Coordination* $\phi_c^{CCB} = 10, \varphi_c^{LTI} = 0$	$\mathcal{W}_c = 0.167, \mathcal{W}_p = 1.813$ $\mathcal{W}_u = 0.866$ (e)	$\mathcal{W}_c = -2.061, \mathcal{W}_p = 3.443$ $\mathcal{W}_u = 0.307$ (f)
	No Coordination $\phi_c^{CCB} = 1.77, \varphi_c^{LTI} = 0.03$	$\mathcal{W}_c = 1.176, \mathcal{W}_p = -0.586$ $\mathcal{W}_u = 0.437$ (g)	$\mathcal{W}_c = 0.308, \mathcal{W}_p = -0.386$ $\mathcal{W}_u = 0.015$ (h)

Table 5.6: National macroprudential policy coordination dilemma: Nash Equilibrium Payoffs Matrix (in terms of unconditional consumption gains from leaving the simple optimal policy)

	Monetary Union			Core			Periphery		
	$sd(\pi_u)$	$sd(y_u)$	$sd(\Delta ctg_u)$	$sd(\pi_c)$	$sd(\Delta y_c)$	$sd(\Delta ctg_c)$	$sd(\pi_p)$	$sd(\Delta y_p)$	$sd(\Delta ctg_p)$
Optimal	0.10	0.8	4.26	0.06	0.71	2.72	0.16	0.93	6.39
Empirical	0.11	0.86	4.22	0.06	0.76	2.69	0.18	1.00	6.33
with individual instruments:									
(a)	0.10	0.8	3.15	0.06	0.71	1.93	0.16	0.93	4.83
(b)	0.11	0.8	3.51	0.06	0.71	1.64	0.17	0.93	6.09
(c)	0.10	0.79	2.79	0.06	0.71	2.53	0.15	0.91	3.14
(d)	0.10	0.79	3.18	0.06	0.70	2.68	0.16	0.91	3.87
with combined instruments:									
(e)	0.10	0.80	2.72	0.05	0.71	1.59	0.16	0.92	4.29
(f)	0.11	0.81	4.08	0.06	0.72	1.7	0.17	0.94	7.37
(g)	0.10	0.79	2.66	0.06	0.71	2.01	0.16	0.91	3.56
(h)	0.10	0.8	3.61	0.06	0.71	1.95	0.16	0.92	5.9

TABLE 5.7: Macroeconomic performances of different policy regimes

First, the cooperative solution based on the regional use of multiple instruments is reported as regime (e) in Table 5.6. As observed, welfare increase at the federal level ($\mathcal{W}_u = 0.866\%$) is higher than the one previously reached with the asymmetric implementation of a single instrument ($\mathcal{W}_u = 0.785\%$). Remarkably, each part of the monetary union gets welfare gains, even if the periphery situation ($\mathcal{W}_p = 1.813\%$) clearly improves with respect to the situation of the core countries ($\mathcal{W}_c = 0.167\%$).

The interest of adopting a granular determination of the value of the instruments can be underlined by contrasting the figures obtained in the regime (e) with the ones obtained by imposing a uniform value to the parameters. In the latter situation, the figures are obtained as follows: $\mathcal{W}_u = 0.005\%$, $\mathcal{W}_c = -0.146\%$, $\mathcal{W}_p = 0.210\%$ with instrument set uniformly as, $\phi_c^{CCB} = \phi_p^{CCB} = 3.58$ and $\varphi_c^{LTI} = \varphi_p^{LTI} = 0$. In this situation, the federal welfare gains are negligible while the center incur losses (instruments are set too high) and the welfare gains of the periphery are limited (as the instruments are set too low).

Second, we evaluate the interest of creating a supranational mechanism such as the ESRB to promote the coordination between countries belonging to the monetary union by studying the enforceability of the optimal cooperative solution with a Nash bargaining game as in Nash Jr (1950, 1953). Following the bargaining theory, we examine how the surplus generated by macroprudential policy will be split between EMU participants when national governments may have an incentive to set unilaterally macroprudential instruments. Here, there are two participants in the game $i = c, p$. Each player considers two possible strategies: *coordination* and *no coordination*. If both players choose to coordinate macroprudential instruments, they maximize the welfare index of the monetary union $\mathcal{W}_u$. If one country i chooses to deviate singly, it maximizes the welfare index of its country $\mathcal{W}_i$ to the detriment of the monetary union. In this situation the existence of an enforceability mechanism is necessary to reach the cooperative equilibrium, as each country may have an incentive to deviate from the cooperative equilibrium. Indeed, as reported in the table, the cooperative equilibrium does not coincide with the Nash equilibrium : i.e., the best situation can not be reached without an external mechanism such as the ESRB.

As reported in Table 5.6 (page 167), we find that each country would choose to follow the non cooperative strategy because incentives to deviate from the cooperative equilibrium are too large. Leaving countries to choose macroprudential governance with multiple instruments set regionally would lead to regime (h). In this situation the increase of welfare represents $\mathcal{W}_c = 0.308\%$ of permanent consumption in the core countries, the decrease of welfare in the periphery represents $\mathcal{W}_p = -0.386\%$ of permanent consumption, both figures leading to a slight average increase of permanent consumption of $\mathcal{W}_u = 0.015\%$, far away from the cooperative outcome of regime (e).

In summary, as already underlined in the case of a single instrument, the Pareto optimal equilibrium cannot be reach on the basis of national incentives. It would thus be necessary to enforce cooperation through federal institutional incentives, such as the one developed through the ESRB initiative.

6.3 Macroeconomic performances

Table 5.7 (page 168) reports the macroeconomic performances of macroprudential policy regimes presented above. We more particularly concentrate our analysis on the consequences of the macroprudential policy on the standard deviation of activity, inflation and the credit to GDP ratio (measuring the evolution of financial imbalances) for the monetary union and for each region.

First, looking at federal figures, we observe that the organization of macroprudential policy has only a marginal impact on both the standard deviation of inflation and activity. In contrast, the choice of the macroprudential regime clearly affects the standard deviation of the credit to GDP ratio. In particular, this standard deviation (reaching 4.26 without macroprudential measures) can falls to 2.72 under the optimal regime (e) combining two macroprudential instruments in both regions.

Second, turning to regional figures, the model reports high heterogeneities regarding both macroeconomic and financial indicators. Overall the core countries are characterized by less instability (the three standard deviations are much lower) than peripheral countries. On average the standard deviation of inflation is one third of the peripheral figure, while the standard deviation of output is around 20% less than the peripheral figure. The choice of macroprudential instruments affects this macroeconomic heterogeneity.

Third, the most striking heterogeneity between regions is reported for the regional standard deviation of the credit to GDP ratio. This standard deviation moves from 2.72 (without macroprudential measures) to 1.59 (in the optimal regime (e)) for the core countries, while it fluctuates sharply between 7.37 (regime (f)) to 3.14 (regime (c)). Noticeably, the lowest value for the standard deviation of the credit to growth ratio does not correspond to the optimal policy regime nor does the highest value corresponds to the optimal monetary policy situation. This feature can be explained by the fact that the criterion used to reach the optimality of the macroprudential policy accounts for the interdependence of regions in the currency union. However, the standard deviation is quite low in the periphery under the optimal macroprudential regime (e)

To understand why the optimal situation in terms of welfare does not corresponds to the situation with the best macroeconomic record, one has to remember that welfare depends on consumption and labour effort. In particular, the consumption smoothing component is a key aspect of welfare. However, the Pareto optimal situation leads to federal macroeconomic results that are rather good as the value for the three standard deviation is rather low. Nevertheless, as observed the lowest value for the standard deviation of the credit to growth ratio is obtained for regime (g) which is not the optimal one.

7 Sensitivity Analysis

In this last section we evaluate the sensitivity of the previous results with a key assumption of the model, namely the possibility of banks to engage in cross border interbank and corporate loans. We more particularly concentrate on the welfare implication related to international financial spillovers by considering a situation where banks do not engage in cross border loans (*i.e.* we impose, $\alpha_i^L = \alpha_i^{IB} = 0$ in the model).

As reported in Table 5.8 (page 174), if each part of the monetary union selects one instrument, the outcome regarding the symmetric/asymmetric choice of the macroprudential tool previously underlined becomes irrelevant with banking autarky, as regional outcomes are positive across all policy regimes (a)-(d). As there is no spillover related to cross border lending, the choice of the macroprudential policy of the other region is clearly nationally less painful in the case of the choice of asymmetric instruments. However, as reported, the choice of the instrument in the core countries has a deep impact on national and federal welfare. The adoption of the lender instrument should be preferred as it leads to a much higher increase in permanent consumption growth. In contrast the choice of the instrument in the peripheral countries has only a very low impact on the final result.

Remarkably, the optimal policy regime on federal grounds is still regime (b). In this situation core countries select an instrument to target the banking sector, while peripheral countries select the instrument oriented towards the borrowers. However, cross-border loan flows are a critical feature to address cooperation incentives issues, as we observe a Nash equilibrium reversal in banking autarky. Now, the Nash equilibrium corresponds to the optimal choice of instruments on union wide welfare. National incentives lead to the optimal outcome: as each country is able to target the origin of regional imbalances (i.e., impose constrains on either lenders or borrowers) without creating spillovers to the other part of the monetary union, there is no need to homogenize instruments as we previously found with cross border lending. Furthermore, as the Nash and optimal equilibria are the same, there is no need to create an exogenous mechanism to reach the optimal equilibrium as long as each part of the monetary union can select a well tailored macroprudential instrument. This result is similar to the one obtained by Quint

& Rabanal (2013) in a model ignoring cross border lending, showing that there was no gain to get from the coordination of macroprudential instruments between the members of a monetary union.

In Table 5.9 (page 174), we report results when both instruments are combined in each region of the Eurozone. As previously noticed for cross border lending, the use of multiple instruments in each region increases welfare in the monetary union. The welfare increase now represents 0.902% of permanent consumption instead of 0.884% when using a single instrument. Furthermore, the core has less incentive to deviate from the coordinated scheme, as it is neutral with respect to this choice. The picture is different for the periphery as peripheral countries clearly favour the non cooperation scheme. Thus combining individual strategies makes the equilibrium indeterminate as it can lie either on regimes (f) and (h).

However, in both regimes (f) and (h) the average union wide permanent consumption increase is lower than the one encountered in the optimal regime (e). Thus cooperation still requires the use of a supranational enforcing mechanism such as the one represented by the ESRB. However, the difference in the value of permanent consumption increases is not as high as the one reported for the situation with cross border lending. As there is no spillover related to cross border lending, there is less loss in welfare increase related to the deviation from the optimal cooperative equilibrium. Thus, implementing uncoordinated regional macroprudential policy without cross border lending is less painful, as there is less spillovers that may dilute the effect of inappropriate macroprudential decisions in other side of the monetary union.

8 Conclusion

This chapter has discussed the degree of homogeneity to be imposed to macroprudential measures for countries belonging to the Eurozone. Assessing the fact that the implementation of the macroprudential mandate has been set on cooperative decisions, we have developed a two-country DSGE model that accounts for some major features of the Eurozone (such as the key role of the banking system, cross-border bank loans or the heterogeneity in financial factors) to provide a quantitative evaluation of welfare gains coming from a more symmetric treatment of countries in the implementation of macroprudential measures. We have separated the Eurozone in two parts (the core and the periphery) and evaluated how a macroprudential policy combining two instruments (namely, bank capital requirements and the evolution of the loan-to-income ratio) should be implemented.

Our main conclusions underline a possible conflict between the federal and the national levels in the implementation of heterogeneous macroprudential measures based on a single instrument as the Pareto optimal situation computed on a federal ground requires an asymmetric choice of instruments, while more symmetric practices should be preferred on regional ground. Second, the adoption of combined instruments in each country solves this potential conflict as it leads to both a higher welfare increase in the Pareto optimal equilibrium and always incurs national welfare gains. However, in all cases, the Pareto optimal equilibrium cannot be reached on national incentives and requires a supranational enforcing mechanism.

These elements should be useful to analyze the proposed evolution of macroprudential policy organization in the Eurozone. There are important welfare gains in implementing national adjusted macroprudential measures, but a federal institution is necessary to oblige EU members to cooperate. Without a federal constraint on macroprudential policy implementation, the Euro members may choose not to coordinate which may significantly reduce the welfare of the Eurosystem.

		PERIPHERY	
		Lender Tool $\phi_p^{CCB} \geq 0$	*Borrower Tool* $\varphi_p^{LTI} \geq 0$
CORE	*Lender Tool* $\phi_c^{CCB} \geq 0$	$\mathcal{W}_c = 0.877,\ \mathcal{W}_p = 0.719$ $\mathcal{W}_u = 0.811$ $\phi_c^{CCB} = 10, \phi_p^{CCB} = 2.94$ (a)	$\mathcal{W}_c = 0.944,\ \mathcal{W}_p = 0.801$ $\mathcal{W}_u = 0.884$ $\phi_c^{CCB} = 10,\ \varphi_p^{LTI} = 0.01$ (b)
	Borrower Tool $\varphi_c^{LTI} \geq 0$	$\mathcal{W}_c = 0.040,\ \mathcal{W}_p = 0.317$ $\mathcal{W}_u = 0.157$ $\varphi_c^{LTI} = 0.01,\ \varphi_p^{CCB} = 4.37$ (c)	$\mathcal{W}_c = 0.040,\ \mathcal{W}_p = 0.326$ $\mathcal{W}_u = 0.161$ $\varphi_c^{LTI} = 0.01,\ \varphi_p^{LTI} = 0.03$ (d)

Table 5.8: Homogenous/heterogenous practices in the conduct of Macroprudential Policy between different areas in the Euro Area in banking autarky: Nash equilibrium payoffs matrix in terms of unconditional consumption gains from leaving the standard optimal monetary policy.

		PERIPHERY	
		Coordination $\phi_p^{CCB} = 1.29, \varphi_p^{LTI} = 0.03$	*No Coordination* $\phi_p^{CCB} = 2.45, \varphi_p^{LTI} = 0.02$
CORE	*Coordination* $\phi_c^{CCB} = 10, \varphi_c^{LTI} = 0$	$\mathcal{W}_c = 0.94, \mathcal{W}_p = 0.849$ $\mathcal{W}_u = 0.902$ (e)	$\mathcal{W}_c = 0.923, \mathcal{W}_p = 0.860$ $\mathcal{W}_u = 0.896$ (f)
	No Coordination $\phi_c^{CCB} = 10, \varphi_c^{LTI} = 0.00$	$\mathcal{W}_c = 0.940, \mathcal{W}_p = 0.849$ $\mathcal{W}_u = 0.902$ (g)	$\mathcal{W}_c = 0.923, \mathcal{W}_p = 0.860$ $\mathcal{W}_u = 0.896$ (h)

Table 5.9: National macroprudential policy coordination dilemma in banking autarky: Nash Equilibrium Payoffs Matrix (in terms of unconditional consumption gains from leaving the simple optimal policy)

General Conclusion

The aim of this thesis is to evaluate the conduct of macroprudential policies in an heterogenous monetary union, such as the Eurozone, by borrowing on the recent theoretical and empirical developments of Dynamic Stochastic General Equilibrium (DSGE) models. Since cross-border lending has become the most important channel of transmission of shocks during the financial episode, a key problem for macroprudential authorities is to account for spillovers coming from international banking. We developed a flexible and tractable framework that accounts for a financial accelerator mechanism with cross border lending and interbank fundings. After the fit exercise, we are able to perform some counterfactual analysis and rank different macroprudential schemes.

The main results obtained in this thesis can be summarized as follows. First regarding the international business cycles generated by cross-border lending, we find that the current account variance since the Euro Area creation has mainly been driven by financial international banking flows. Furthermore, cross-border lending has contributed to a better mutualization of the negative consequences of the financial crisis over the region by transferring the volatility from peripheral to core countries. In addition, we find that the model fit is strongly improved with cross-border banking flows, suggesting that it is a key pattern of the business and credit cycles of the Eurosystem that should be included in the next generation of open economy models for policy analysis.

Second, turning to macroprudential policy implementation, we find that macroprudential policy improves welfare at the global level with respect to the conduct of an optimal monetary policy. Among all the implementation schemes, the highest welfare gains are observed when countries use multiple instruments and when macroprudential policy is implemented in a granular fashion.

However, the conduct of macroprudential policy based on the maximization of the welfare of a representative Eurozone agent is not a free lunch for participating countries as in most situations, peripheral countries are winners while core countries record either smaller welfare gains or even welfare losses.

Third, the heterogeneity of welfare results observed at the national levels questions the implementability of macroprudential schemes following national incentives. In particular reaching the Pareto optimal equilibrium of the Eurozone may incur welfare losses for core countries. In many policy experiments, we find that there exists an equilibrium that combines welfare increases at both the global and national levels for all participants, but its enforceability requires a federal action (thus justifying the existence of a coordination mechanism such as the ESRB in the Eurozone).

Finally our results underline the critical role of cross-border loans to assess the consequences of macroprudential policy measures in the Eurozone. The possibility of banks to engage in cross-border lending introduces an important spillover channel that tends to increase the welfare gains associated to macroprudential measures. Ignoring this phenomenon may lead to fallacious results in terms of the welfare ranking of alternative implementation schemes.

Looking forward, our analysis outlines several areas for future research. In particular, our model could be used as a framework to assess the interaction between unconventional monetary policy and macroprudential policy. It could be also extended to account for time-varying share of liquid/illiquid bank on the interbank market to offer an alternative to the canonical model of Gertler & Karadi (2011) for unconventional monetary policy analysis. Finally, some robustness check could be performed regarding the results after incorporating an housing market in the model.

Appendix A

The Non-Linear Model Derivations

This appendix presents the derivations of Chapter 5 model, as it is the most advanced and complete model of the thesis that accounts for main features of the analysis. This appendix aims at helping the reader in understanding how to derive the models of Chapter 2, Chapter 3 and Chapter 4. There are some differences between all the models developed in this thesis either the size of each area, the way of closing the model or the microfoundation of mark-up shocks.

First in Chapter 2 and Chapter 4, we develop a symmetric model with countries equal in size such that $n_c = n_p = 1$ (or $n_h = n_f = 1$). Then the aggregation function become simple to handle:

$$\mathcal{G}\left(X_{i,t}\left(x\right)\right) = \begin{cases} \int_0^1 X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = c \text{ (or } h) \\ \int_0^1 X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = p \text{ (or } f) \end{cases}$$

while for countries/areas not equal in size $n_c \neq n_p$ (Chapter 3 and Chapter 5), we have,

$$\mathcal{G}\left(X_{i,t}\left(x\right)\right) = \begin{cases} \int_0^{n_c} X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = c \\ \int_{n_c}^{n_c+n_p} X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = p \end{cases} \tag{A.1}$$

Second, we use two different ways of closing open-economy models in this thesis. In Chapter 2 and Chapter 4, as we are interested in the spillovers of cross-border lending on the current account, we close the model by assuming that home and foreign households exchange risk-free bonds. Thus, asset market equilibrium implies that the world net supply of bonds is zero, the same applies to current accounts excess and deficits, $B_{h,t+1} + B_{f,t+1} = 0$ and $CA_{h,t} + CA_{f,t} = 0$. In contrast in Chapter 3 and Chapter 5, we focus on the bank balance sheet constraint, households savings are given to banks as deposits. As consequence, deposits appear in the bank balance sheet (*e.g.* $D_{i,t} + L^{RF}_{i,t} = L^{s}_{i,t}$ in Chapter 3).

Third, in Chapter 2 and Chapter 4, we simplify the steady state assuming that mark-ups are canceled by governments as Benigno & Woodford (2005). This assumption is helpful in solving the financial contract of entrepreneurs in the non-stochastic steady state. In Chapter 3, we use micro-founded time-varying markups for credit and deposits rates. This version is interesting for the fit exercise, but in the log-linear version of the model, mark-up shocks are affected by the calvo probability. As consequence the size of mark-ups shocks are not clearly comparable. In Chapter 5, we follow the implicit assumption of Smets & Wouters (2003) by correcting mark-up shocks by a scale parameter that normalizes to unity the impact of shocks in the log-deviation form of the model. This way, we are able to compare mark-up shocks on a common basis.

Finally, for any interest rate denoted R_t, we use the following notation: $R_t = 1 + r_{t.}$.

The rest of this appendix is organized as follows: Section 1 presents the non-linear model used in Chapter 5. Section 2 introduces computational tricks to perform higher order approximations to the policy function.

1 The Non-Linear Model

The two countries share a common currency but are not equal in size. Our model describes a monetary union made of two asymmetric countries $i \in \{c, p\}$ (where c is for Core and p for periphery) of relative sizes n_c and n_p inspired by (Kolasa, 2009). Each country is populated by households that consume save and supply labor. Intermediate firms supply differentiated goods in a monopolistically competitive market and set prices in a staggered basis. Final producers are CES packers, they aggregate the differentiated goods from intermediate firms and sell it to households and capital producers. Capital producers recycle the used capital stock and invest new capitals. Entrepreneurs buy capitals from capital producers and sell it to intermediate firms. Entrepreneurs are credit constrained, they borrow funds to the banking system. Banks provide loans to entrepreneurs and deposit services in a monopolistically competitive market and set interest rate in staggered contracts. Banks are not homogenous, they are either liquid or illiquid according to their access to ECB fundings leading to an international interbank market where liquid banks provides interbank loans to both home and foreign banks.

We aggregate households, firms, entrepreneurs and banks using the following aggregator for agent $x \in [0,1]$,

$$\mathcal{G}\left(X_{i,t}\left(x\right)\right) = \begin{cases} \int_0^{n_c} X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = c \\ \int_{n_c}^{n_c+n_p} X_{i,t}\left(x\right) \mathrm{d}x \text{ for } i = p \end{cases} \tag{A.2}$$

1.1 The households utility maximization problem

In each economy there is a continuum of identical households who consume, save and work in intermediate firms. The total number of households is normalized to 1. The representative household j maximizes the welfare index:

$$\max_{\left\{C_{i,t}(j),H_{i,t}(j),D^d_{i,t+1}(j)\right\}} \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} e^{\varepsilon^U_{i,t+\tau}} \left[\frac{\left(C_{i,t+\tau}\left(j\right) - h^C_i C_{i,t-1+\tau}\right)^{1-\sigma^C}}{1-\sigma^c} - \chi_i \frac{H_{i,t+\tau}\left(j\right)^{1+\sigma^L}}{1+\sigma^L} \right], \tag{A.3}$$

subject to:

$$\frac{W^h_{i,t}}{P^C_{i,t}} H_{i,t}\left(j\right) + \left(1 + r^D_{i,t-1}\right) \frac{D^d_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{\Pi^Y_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{\bar{M}_i\left(j\right)}{P^C_{i,t}} = C_{i,t}\left(j\right) + \frac{D^d_{i,t+1}\left(j\right)}{P^c_{i,t}} + \frac{T_{i,t}\left(j\right)}{P^C_{i,t}} + \frac{P_{i,t}}{P^C_{i,t}} AC^D_{i,t}\left(j\right). \tag{A.4}$$

Here, $C_{i,t}\left(j\right)$ is the consumption index, $h^C_i \in [0,1]$ is a parameter that accounts for consumption habits, $H_{i,t}\left(j\right)$ is labour effort, $\varepsilon^U_{i,t}$ is an exogenous $AR(1)$ shock to household preferences. The income of the representative household is made of labour income (with the desired nominal wage $W^h_{i,t}$ and the consumption price index $P^C_{i,t}$), interest payments for deposit services, (where $D^d_{i,t}\left(j\right)$ stands for the deposits services supplied by banks and subscribed in period $(t-1)$ and $r^D_{i,t-1}$ is the nominal rate of deposits between period $t-1$ an period t), and earnings from shareholdings (where $\Pi^Y_{i,t}\left(j\right)$ are the nominal amount of dividends he receives from final good producers). The representative household spends this income on consumption, deposits and tax payments (for a nominal amount of $T_{i,t}\left(j\right)$). Finally, we assume that the household has to pay quadratic adjustment costs to buy new deposits, according to the function, $AC^D_{i,t}\left(j\right) = \frac{\chi^D_i}{2}(D^d_{i,t+1}\left(j\right) - \bar{D}_i\left(j\right))^2/\bar{D}_i\left(j\right)$, where $\bar{D}_i\left(j\right)$ is the steady state level of deposits.

Letting $\lambda^c_{i,t}$ denotes the Lagrangian multiplier of the household budget balance sheet, the first order conditions that solve this problem can be summarized with a Euler deposit condition:

$$\frac{\beta\left(1 + r^D_{i,t}\right)}{1 + P_{i,t} AC^{D\prime}_{i,t}\left(j\right)} = \mathbb{E}_t \left\{ \frac{e^{\varepsilon^U_{i,t}}}{e^{\varepsilon^U_{i,t+1}}} \frac{P^C_{i,t+1}}{P^C_{i,t}} \left(\frac{\left(C_{i,t+1}\left(j\right) - h^C_i C_{i,t}\right)}{\left(C_{i,t}\left(j\right) - h^C_i C_{i,t-1}\right)} \right)^{\sigma^C} \right\}, \tag{A.5}$$

and a labour supply function:

$$\frac{W_{i,t}^{h}}{P_{i,t}^{C}} = \chi_i H_{i,t}\left(j\right)^{\sigma^L}\left(C_{i,t}\left(j\right) - h_i^C C_{i,t-1}\right)^{\sigma^C}. \tag{A.6}$$

1.2 Labor Unions

Households provide differentiated labor types j, sold by labor unions to perfectly competitive labor packers who assemble them in a CES aggregator and sell the homogenous labor to intermediate firms. Labor packers are perfectly competitive and maximize profits subject to the supply curve:

$$\begin{aligned} &\max\nolimits_{H_{i,t}(j)} W_{i,t}H_{i,t}^{d} - \mathcal{G}\left(W_{i,t}\left(j\right)H_{i,t}\left(j\right)\right) \\ s.t. H_{i,t}^{d} &= \left[\left(\tfrac{1}{n_i}\right)^{1/\epsilon_W}\mathcal{G}\left(H_{i,t}\left(j\right)^{(\epsilon_W-1)/\epsilon_W}\right)\right]^{\epsilon_W/(\epsilon_W-1)} \end{aligned}$$

where $H_{i,t}^{d}$ is the aggregate demand from intermediate firms. Thus relative labour demand writes:

$$H_{i,t}\left(j\right) = \frac{1}{n_i}\left(\frac{W_{i,t}(j)}{W_{i,t}}\right)^{-\epsilon_W} H_{i,t}^{d}, \quad \forall j. \tag{A.7}$$

Using the zero profit condition, the aggregate wage index of all labor varieties in the economy writes:

$$W_{i,t} = \left[\frac{1}{n_i}\mathcal{G}\left(W_{i,t}\left(j\right)^{1-\epsilon_W}\right)\right]^{\frac{1}{1-\epsilon_W}}. \tag{A.8}$$

Concerning the representative unions j, they are an intermediate between households and the labor packers. The wage evolves according to:

$$W_{i,t}(j) = \begin{cases} W_{i,t}^{*}\left(j\right) \text{ with probability } 1-\theta_i^W \\ \left(\pi_{i,t-1}^{C}\right)^{\xi_i^W} W_{i,t-1}\left(j\right) \text{ with probability } \theta_i^W \end{cases}.$$

Trade unions are not allowed to renegotiate the wage with probability θ_i^W, then the wage is partially indexed on previous inflation of consumption goods at a degree $\xi_i^W \in [0,1]$. Assuming that the trade union is able to modify its wage with a probability $1-\theta_i^W$, it chooses the optimal wage $W_{i,t}^{*}\left(i\right)$ to maximize its expected sum of profits by solving:

$$\max_{\{W_{i,t}^{*}(j)\}} \mathbb{E}_t\left\{\sum\nolimits_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\left[\frac{W_{i,t}^{*}\left(j\right)}{P_{i,t+\tau}^{C}}\prod_{k=1}^{\tau}\left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^W} - \frac{W_{i,t+\tau}^{h}\left(j\right)}{P_{i,t+\tau}^{C}}\right]H_{i,t+\tau}\left(j\right)\right\},$$

subject to the downgrade sloping demand constraint from labor packers:

$$H_{i,t+\tau}\left(j\right) = \frac{1}{n_i}\left(\frac{W_{i,t}^{*}\left(j\right)}{W_{i,t+\tau}}\prod\nolimits_{k=1}^{\tau}\left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^W}\right)^{-\epsilon^W} H_{i,t+\tau}, \ \forall\tau > 0,$$

where $H_{i,t}(j)$ denotes the quantity of differentiated labor types j that is used in the labor packer production with time-varying substitutability ε_W between different labor varieties. The first order condition results in the following equation for the re-optimized real wage:

$$\frac{W^*_{i,t}(j)}{P^c_{i,t}} = \frac{\mathbb{E}_t \sum_{\tau=0}^{\infty} \left(\theta_i^W \beta\right)^{\tau} \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \frac{\varepsilon_W}{\varepsilon_W - 1} e^{\gamma_i^W \varepsilon^W_{i,t+\tau}} \frac{W^h_{i,t+\tau}(j)}{P^C_{i,t+\tau}} H_{i,t+\tau}(j)}{\mathbb{E}_t \sum_{\tau=0}^{\infty} \left(\theta_i^W \beta\right)^{\tau} \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \prod_{k=1}^{\tau} \frac{\left(\pi^C_{i,t+k-1}\right)^{\xi_i^W}}{\pi^C_{i,t+k}} H_{i,t+\tau}(j)}, \tag{A.9}$$

where $\varepsilon^W_{i,t}$ is an *ad hoc* cost-push shock to the real wage equation following an AR(1) process and $\gamma_i^W \geq 0$ is a parameter[1].

In Figure A.1, we plot alternative indicators to assess how well the model can fit the data using a nominal friction on wage adjustments. As reported, we see that the wage stickiness tends to dampen the wage response to both supply and demand shocks in Figure A.1.a and b. We also see that the model is able to replicate the distribution of the real wage growth observed in the data. Finally, we observe in Figure A.1.d and e that this friction does not improve the autocorrelation and the dynamic correlation with output fits.

1.3 The Final Goods Sector

This sector is populated by two groups of agents: intermediate firms and one final firm. Intermediate firms produce differentiated goods i, decide on labour and capital inputs on a perfectly competitive inputs market, and set prices according to the Calvo model. The final good producer act as a consumption bundler by combining national intermediate goods to produce the homogenous final good.

The final good producers is perfectly competitive and maximizes profits subject to the supply curve:

$$\begin{aligned} &\max_{Y_{i,t}(i)} P_{i,t} Y^d_{i,t} - \mathcal{G}\left(P_{i,t}(i)\, Y_{i,t}(i)\right) \\ s.t. \quad & Y^d_{i,t} = \left[\left(\frac{1}{n_i}\right)^{1/\epsilon_P} \mathcal{G}\left(Y_{i,t}(i)^{(\epsilon_P - 1)/\epsilon_P}\right)\right]^{\epsilon_P/(\epsilon_P - 1)} . \end{aligned}$$

We find the intermediate demand functions associated with this problem are:

$$Y_{i,t}(i) = \frac{1}{n_i} \left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P} Y^d_{i,t}, \qquad \forall i, \tag{A.10}$$

[1] The exogenous shock is affected by γ_i^W to normalize to unity (or very close to unity) the impact of the shock $\varepsilon^W_{i,t}$ in the log deviation form of the model as in Smets & Wouters (2007), such that $\gamma_i^W = \theta_i^W / \left[\left(1 - \beta\theta_i^W\right)\left(1 - \theta_i^W\right)\right]$.

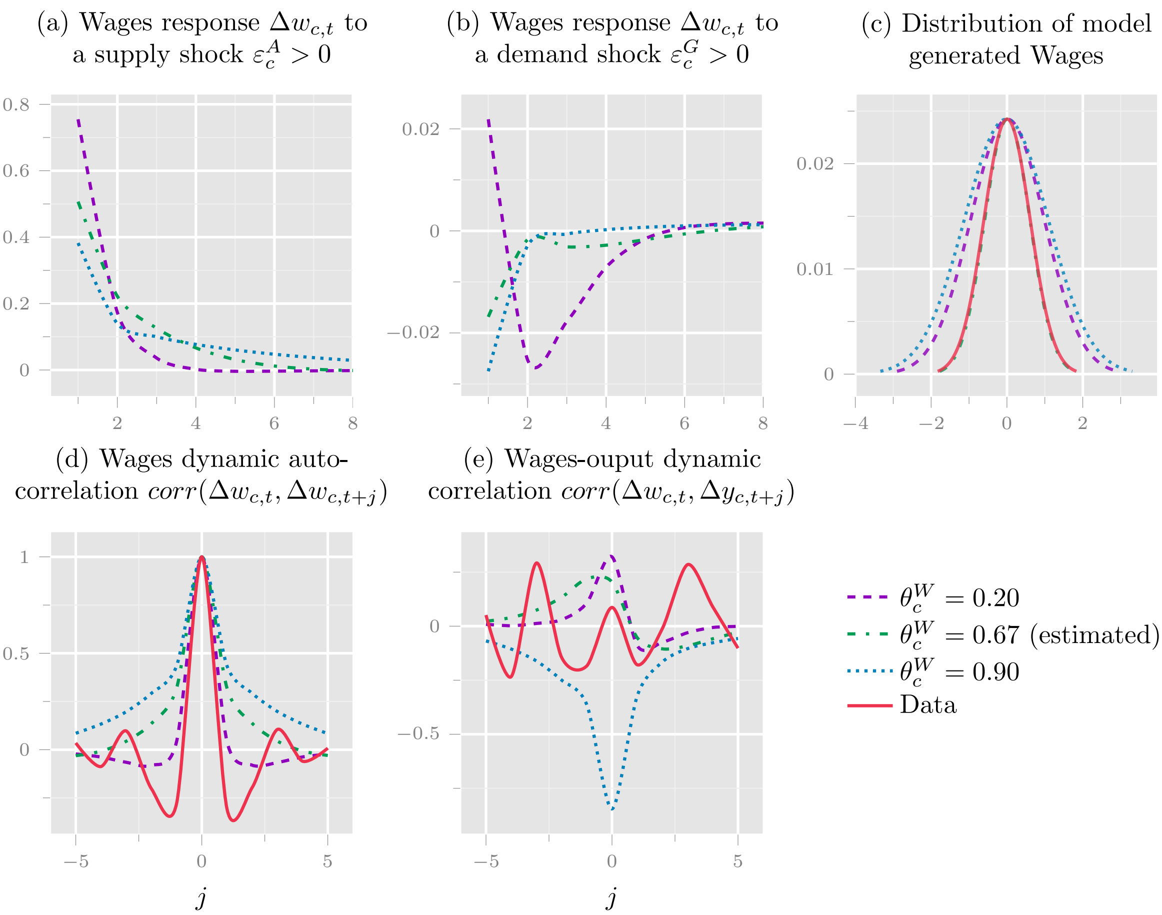


FIGURE A.1: The role of sticky wages in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

where $Y^d_{i,t}$ is the aggregate demand. Thus the aggregate price index of all varieties in the economy writes:

$$P_{i,t} = \left[\frac{1}{n_i}\mathcal{G}\left(P_{i,t}\left(i\right)^{1-\epsilon_P}\right)\right]^{\frac{1}{1-\epsilon_P}}. \tag{A.11}$$

1.4 The Intermediate Goods Sector

The representative intermediate firm i has the following technology:

$$Y_{i,t}\left(i\right) = e^{\varepsilon^A_{i,t}} K_{i,t}\left(i\right)^{\alpha} H^d_{i,t}\left(i\right)^{1-\alpha}, \tag{A.12}$$

where $Y_{i,t}\left(i\right)$ is the production function of the intermediate good that combines capital $K_{i,t}\left(i\right)$, labour demand $H^d_{i,t}\left(i\right)$ to household and technology $e^{\varepsilon^A_{i,t}}$. Here, $e^{\varepsilon^A_{i,t}}$ is an $AR(1)$ productivity shock.

Intermediate goods producers solve a two-stage problem. In the first stage, taken the input prices $W_{i,t}$ and $Z_{i,t}$ as given, firms rent inputs $H^d_{i,t}\left(i\right)$ and $K_{i,t}\left(i\right)$ in a perfectly competitive factor market in order to minimize costs subject to the production constraint in Equation A.12. Combining the first order conditions with the production function leads to the real marginal cost expression:

$$\frac{MC_{i,t}\left(i\right)}{P^C_{i,t}} = \frac{MC_{i,t}}{P^C_{i,t}} = \frac{1}{e^{\varepsilon^A_{i,t}}}\left(\frac{Z_{i,t}}{P^C_{i,t}}\right)^{\alpha}\left(\frac{W_{i,t}}{P^C_{i,t}}\right)^{(1-\alpha)}(1-\alpha)^{-(1-\alpha)}\alpha^{\alpha}. \tag{A.13}$$

Inputs must also satisfy:

$$\alpha\frac{W_{i,t}}{P^C_{i,t}}H^d_{i,t}\left(i\right) = (1-\alpha)\frac{Z_{i,t}}{P^C_{i,t}}K_{i,t}\left(i\right). \tag{A.14}$$

In the second-stage, firm i set prices according to a Calvo mechanism, each period firm i is not allowed to reoptimize its price with probability θ^P_i but price increases of $\xi^P_i \in [0,1]$ at last period's rate of price inflation, $P_{i,t}\left(i\right) = \pi^{\xi^P_i}_{i,t-1}P_{i,t-1}\left(i\right)$. The final firm allowed to modify its selling price with a probability $1-\theta^P_i$ chooses $\left\{P^*_{i,t}(i)\right\}$ to maximize its expected sum of profits:

$$\max_{\left\{P^*_{i,t}(i)\right\}} \mathbb{E}_t\left\{\sum_{\tau=0}^{\infty}\left(\theta^P_i\beta\right)^{\tau}\frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}}\left[P^*_{i,t}\left(i\right)\prod_{k=1}^{\tau}\pi^{\xi^P_i}_{i,t+k-1} - MC_{i,t+k}\right]Y_{i,t+\tau}\left(i\right)\right\},$$

under the demand constraint from final goods producers:

$$Y_{i,t+\tau}\left(i\right) = \frac{1}{n_i}\left(\frac{P^*_{i,t}\left(i\right)}{P_{i,t+\tau}}\prod_{k=1}^{\tau}\pi^{\xi^P_i}_{i,t+k-1}\right)^{-\epsilon_P}Y^d_{i,t+\tau},\ \forall\ \tau > 0,$$

where $Y_{i,t}^{d}$ represents the quantity of the goods demanded in country i and $\lambda_{i,t}^{c}$ is the household marginal utility of consumption. The first order condition that defines the price of the representative firm i is:

$$P_{i,t}^{*}(i)=\frac{\mathbb{E}_t\left\{\sum_{\tau=0}^{\infty}\left(\theta_i^P\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\frac{\epsilon_P}{(\epsilon_P-1)}e^{\gamma_i^P\varepsilon_{i,t}^{P}}MC_{i,t+k}Y_{i,t+\tau}\left(i\right)\right\}}{\mathbb{E}_t\left\{\sum_{\tau=0}^{\infty}\left(\theta_i^P\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\prod_{k=1}^{\tau}\pi_{i,t+k-1}^{\xi_i^P}Y_{i,t+\tau}\left(i\right)\right\}}. \tag{A.15}$$

where $\varepsilon_{i,t}^{P}$ is an *ad hoc* cost-push shock to the inflation equation following an AR(1) process and $\gamma_i^P\geq 0$ is a parameter[2].

In Figure A.4 , we plot alternative ways to address issues related the model fit. In Figure A.4.a and b, we see that the stickier the price are, the lower is the price response to supply and demand shocks. We also note that the model is able to replicate the data distribution in Figure A.4.c. This nominal friction is also useful to account for the price autocorrelation compared to a situation where price are very sticky. In the last figure, we see this friction does not help in catching up the dynamic correlation with output.

1.5 Entrepreneurs

Each intermediate firm hires labour freely, but requires funds to finance the renting of capital needed to produce the intermediate good. The amount of capital to be financed by the representative entrepreneur is equal to $Q_{i,t}K_{i,t+1}\left(e\right)$, where $Q_{i,t}$ is the price of capital. This quantity is financed by two means: the net wealth of entrepreneur e, $N_{i,t}\left(e\right)$, and the amount that is borrowed by the entrepreneur from the banking system, $L_{i,t+1}\left(e\right)$.

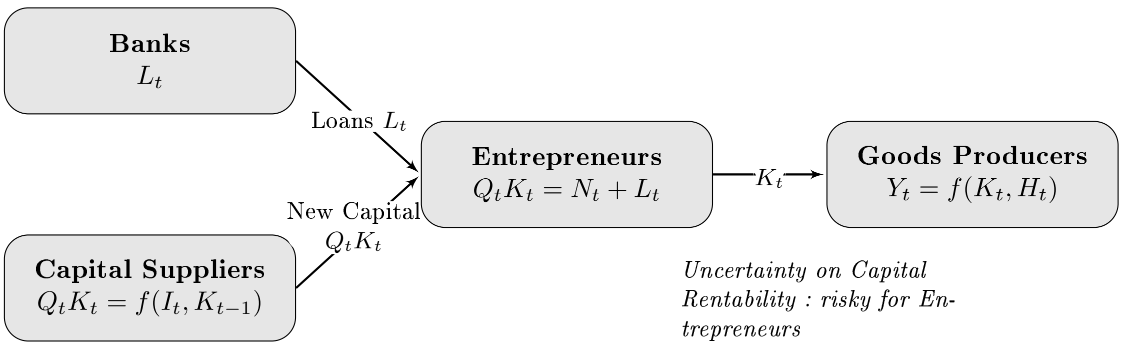


FIGURE A.2: Implementing the financial accelerator in a real business cycle model

[2]The exogenous shock is affected by γ_i^P to normalize to unity (or very close to unity) the impact of the shock $\varepsilon_{i,t}^{P}$ in the log deviation form of the model as in Smets & Wouters (2007), such that $\gamma_i^P=\theta_i^P/\left[\left(1-\beta\theta_i^P\right)\left(1-\theta_i^P\right)\right]$.

1.5.1 The Balance Sheet

The entrepreneur balance sheet writes:

$$Q_{i,t}K_{i,t+1}(e) = L^{\mathcal{H}}_{i,t+1}(e) + N_{i,t+1}(e), \tag{A.16}$$

where $L^{\mathcal{H}}_{i,t+1}(e)$ stands for lending demand with external habits h^L_i to fit the data implying that:

$$L^{\mathcal{H}}_{i,t+1}(e) = L_{i,t+1}(e) - h^L_i\left(L_{i,t} - \bar{L}_i\right).$$

Concerning these external habits, $L^{\mathcal{H}}_{i,t+1}(e)$, when there is no habits such that $h^L_i = 0$, then $L^{\mathcal{H}}_{i,t+1}(e) = L_{i,t+1}(e)$, thus loans habits disappears in steady state $L^{\mathcal{H}}_i(e) = \bar{L}_i(e)$.

In Figure A.6, we plot different indicators to assess the role of demand habits in catching the business cycles statistics of the Euro Area. First, we observe this friction tends to increase the credit growth persistence after a shock (Figure a and b). We also see on Figure c that these habits slightly deteriorate the distribution fit with the data, however the high persistence of the credit supply is perfectly caught by the model as underlined by the autocorrelation in Figure c. Finally, this friction does not improve the fit of the correlation with output growth.

1.5.2 The Distribution of Risky Investment Projects

We assume that each entrepreneur e conducts a mass $\omega \in [\omega_{\min}, +\infty)$ of heterogeneous investment projects, they are risky so that some of the projects will have negative profits. To model individual riskiness, we assume that the aggregate return of investment projects $r^k_{i,t}$ is multiplied by a random value ω, so that the net return of its individual project is, $\omega\left(1 + r^k_{i,t}\right)$. Since he must repay to the bank $L^{\mathcal{H}}_{i,t+1}(e)$ given a borrowing rate $p^L_{i,t}(e)$, the net profit of the project ω is $\omega\left(1 + r^k_{i,t}\right)Q_{i,t-1}K_{i,t}(e,\omega) - \left(1 + p^L_{i,t-1}(e)\right)L^{\mathcal{H}}_{i,t}(e,\omega)$. To separate profitable investment project from non-profitable ones, there exists a critical value (a cutoff point) defined as $\omega^C_{i,t}(e)$ such that the project just breaks even. Thereby the threshold is computed by:

$$\omega^C_{i,t}(e)\left(1 + r^k_{i,t}\right)Q_{i,t-1}K_{i,t}\left(e, \omega^C_{i,t}\right) = \left(1 + p^L_{i,t-1}(e)\right)L^{\mathcal{H}}_{i,t}\left(e, \omega^C_{i,t}\right). \tag{A.17}$$

We assume that the level of the individual profitability affects the survival of the entrepreneur:

- for a high realization of the ω, namely $\omega \geq \omega^C_{i,t}(e)$, the entrepreneur's ω^{th} project is profitable;

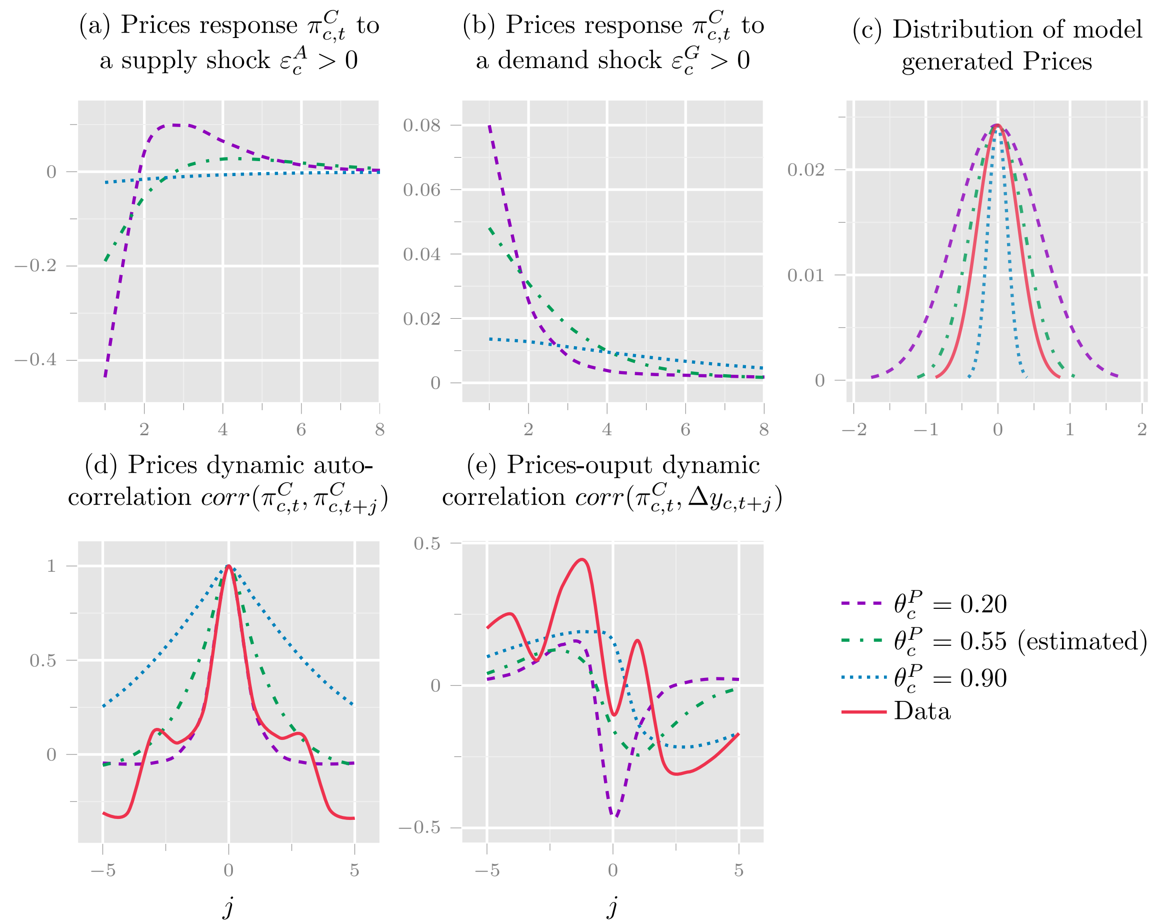


FIGURE A.4: The role of sticky prices in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

- for a low realization of ω, namely $\omega < \omega_{i,t}^{C}$, the entrepreneur's ω^{th} project is not gainful, and he does not make any repayment to the banking system.

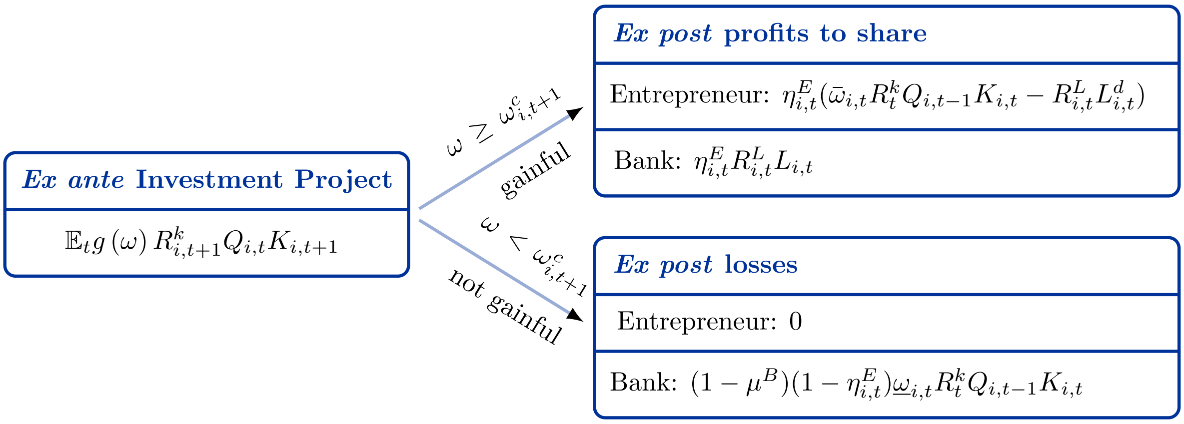


Figure A.3: Profit sharing between the entrepreneur and the bank (in chapter 2 and 4, $\mu^B = 1$).

By assuming that entrepreneurs projects are drawn from a Pareto distribution, then $\omega \sim \mathcal{P}(\kappa, \omega_{\min})$ where $\omega \in [\omega_{\min}, +\infty[$, κ is the shape parameter and $\omega_{\min}$ is the minimum bound of ω. Aggregating the financial contracts, we define the conditional expectation of ω when entrepreneur's project is gainful by, $\eta^E \bar{\omega} = \int_{\omega^C}^{\infty} \omega f(\omega) \mathrm{d}\omega$, while the conditional expectation of ω when entrepreneur's project is insolvent by, $(1-\eta^E)\underline{\omega} = \int_{\omega_{\min}}^{\omega^C} \omega f(\omega) \mathrm{d}\omega$. The share of profitable projects is computed as, $\eta^E = \Pr\left[\omega \geq \omega^C\right] = \int_{\omega^C}^{\infty} f(\omega) \mathrm{d}\omega = \left(\omega_{\min}/\omega^C\right)^k$. The conditional expectation is computed via, $\bar{\omega} = E\left[\omega | \omega \geq \omega^C\right] = \int_{\omega^C}^{\infty} \omega f(\omega) \mathrm{d}\omega / \int_{\omega^C}^{\infty} f(\omega) \mathrm{d}\omega = \frac{\kappa}{\kappa-1}\omega^C$. Since $E[\omega] = \eta^E E\left[\omega | \omega \geq \omega^C\right] + \left(1-\eta^E\right) E\left[\omega | \omega < \omega^C\right] = 1$, then $\underline{\omega} = \left(1-\eta^E \bar{\omega}\right) / \left(1-\eta^E\right)$.

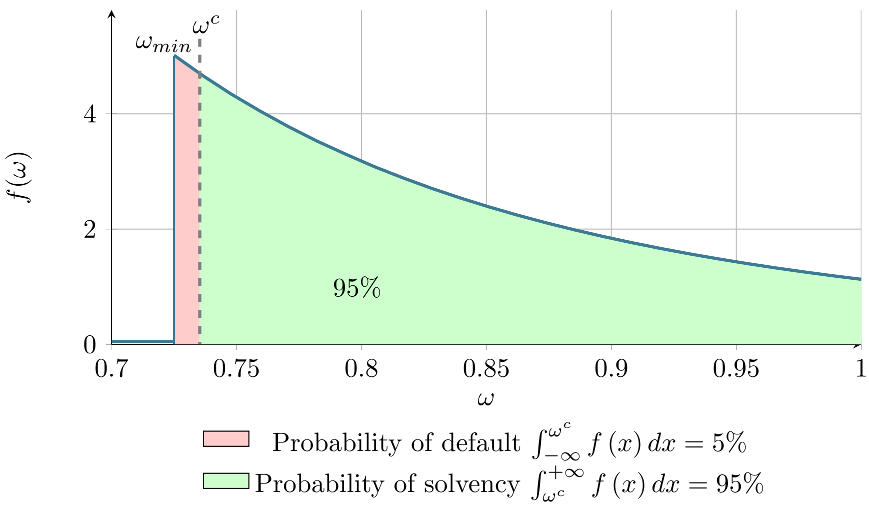


Figure A.5: Pareto distribution of heterogenous entrepreneurs' projects $\omega \in [\omega_{\min}, +\infty[$

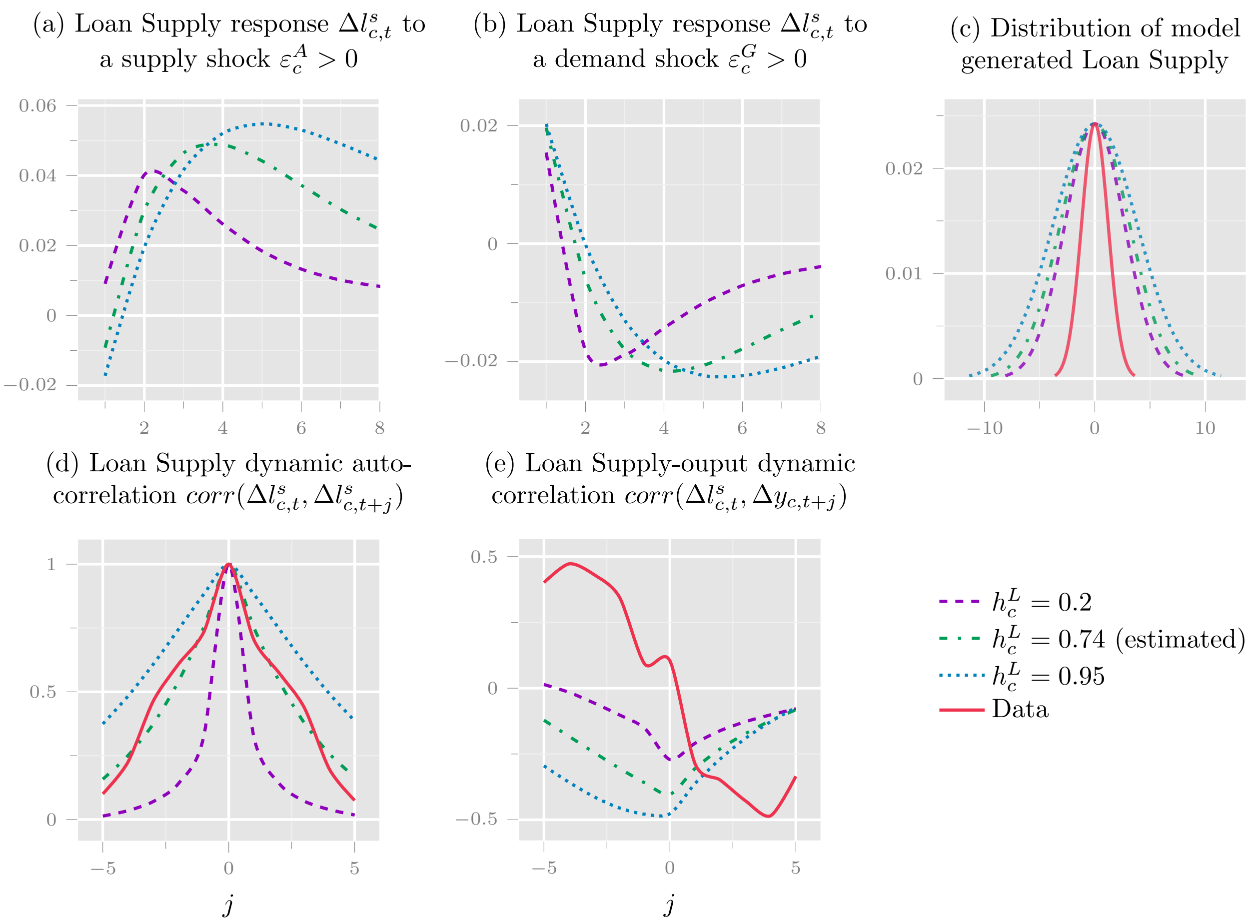


FIGURE A.6: The role of loan demand habits in matching the business cycles of the Euro Area (*generated from chapter 5 model*).

The aggregation of financial projects ω, $\int_{\bar{\omega}_{i,t+1}}^{+\infty} \omega R_{i,t+1}^{k} Q_{i,t} K_{i,t+1}(e,\omega) \mathrm{d}F(\omega)$, leads to the following expression of the expected profitability:

$$\Pi_{i,t+1}^{E}(e) = \mathbb{E}_t \begin{cases} \bar{\omega}_{i,t+1}\left(1+r_{i,t+1}^{k}\right) Q_{i,t} K_{i,t+1}(e) - \left(1+p_{i,t}^{L}(e)\right) L_{i,t+1}^{\mathcal{H}}(e) \text{ with probability } \eta_{i,t+1}^{E} \\ 0 \text{ with probability } 1-\eta_{i,t+1}^{E} \end{cases}. \tag{A.18}$$

1.5.3 Profit Maximization and the Financial Accelerator

To introduce a financial accelerator mechanism, we borrow a concept of De Grauwe (2010) applied in a different context, by assuming that entrepreneurs' forecasts regarding the aggregate profitability of a given project $\bar{\omega}_{i,t}(e)$ are optimistic (*i.e.*, biased upwards)[3]. The perceived *ex ante* value of profitable projects is defined by the isoleastic function:

$$g\left(\bar{\omega}_{i,t+1}, \varepsilon_{i,t}^{Q}\right) = \gamma_i \left(\bar{\omega}_{i,t+1}\right)^{\frac{\varkappa_i}{(\varkappa_i-1)}},$$

where $\varkappa_i$ is the elasticity of the external finance premium[4] and γ_i is a scale parameter[5]. Thus, *ex-ante* the entrepreneur chooses a capital value of $K_{i,t+1}(e)$ that maximizes its expected profit defined as:

$$\max_{\{K_{i,t+1}(e)\}} \mathbb{E}_t \left\{\eta_{i,t+1}^{E}\left[g\left(\bar{\omega}_{i,t+1}\right)\left(1+r_{i,t+1}^{k}\right) Q_{i,t} K_{i,t+1}(e) - \left(1+p_{i,t}^{L}(e)\right) L_{i,t+1}^{\mathcal{H}}(e)\right]\right\}. \tag{A.19}$$

Using the characteristics of the Pareto distribution, the expected spread required by representative entrepreneur e to undertake the decision to finance firms' investment is:

$$S_{i,t}(e) = \frac{1+\mathbb{E}_t r_{i,t+1}^{k}}{1+p_{i,t}^{L}(e)} = \gamma_i^{\varkappa_i - 1}\left[\frac{\kappa}{\kappa-1}\left(1-\frac{N_{i,t+1}(e)}{Q_{i,t}K_{i,t+1}(e)}\right)\right]^{\varkappa_i}. \tag{A.20}$$

The size of the accelerator is determined by the elasticity of the external finance premium $\varkappa_i$. For $\varkappa_i > 0$, the external finance premium is a positive function of the leverage ratio, $Q_{i,t}K_{i,t+1}(e)/N_{i,t+1}(e)$, so that an increase in net wealth induces a reduction of the external finance premium. This phenomenon disappears if $\varkappa_i = 0$. Furthermore, a

[3] Assuming optimistic firms is motivated empirically, Bachmann & Elstner (2013) find evidence of such expectations for German firms using microdata. This hypothesis of the expectations of the private sector is very close to the utility functions introduced by Goodhart et al. (2005) for bankers. In our setting, the financial accelerator does not result from a moral hazard problem but rather from a bias in the expectations of the private sector.

[4] The elasticity of the external finance premium expresses the degree of bias in estimating the expected rentability of entrepreneurs' projects such that if $\bar{\omega} > 1$ and $\varkappa_i > 0$ then $g(\bar{\omega}) > \bar{\omega}$. Expressed *à la* De Grauwe (2010), $\mathbb{E}_t^{opt}\bar{\omega}_{i,t+1} = \mathbb{E}_t \gamma_i \left(\bar{\omega}_{i,t+1}\right)^{\varkappa_i/(\varkappa_i-1)}$ where $\mathbb{E}_t^{opt}$ is the expectation operator of optimistic entrepreneurs.

[5] This parameter is needed to make the steady state independent of $\varkappa_i$,such that $\gamma_i = \bar{\omega}^{1/(1-\varkappa_i)}$.

shock that hits the entrepreneur net wealth $N_{i,t+1}(e)$ will also affect the rentability of the physical capital in the economy. As the rentability of capital is a cost for the intermediate sector, a variation in the net wealth will have aggregate consequences on goods supply through the channel of the capital market as underlined by Gilchrist, Sim, & Zakrajsek (2009). The amount of capital of non-profitable entrepreneurs' investment projects is consumed in terms of home final goods $P_{i,t}\left(1-\eta_{i,t}^{E}\right)\underline{\omega}_{i,t}(e)\left(1+r_{i,t}^{k}\right)Q_{i,t-1}K_{i,t}(e)$. Thus the net wealth of the entrepreneur in the next period is equal to,

$$N_{i,t+1}(e)=\left(1-\tau_{i}^{E}\right)\frac{\Pi_{i,t}^{E}(e)}{e^{\varepsilon_{i,t}^{N}}}, \tag{A.21}$$

where $\varepsilon_{i,t}^{N}$ is an exogenous process of net wealth destruction and τ_{i}^{E} is a proportional tax on the profits of the bank.

In Figure A.7, we examine different indicators to assess the role of the financial accelerator in explaining the data. As reported, our micro-founded financial accelerator is able to replicate the acceleration effect on the volatility of investment after a supply and a demand shock (Figure a and b). However, the financial accelerator has a very low effect on the data fit. As explained in Chapter 4, this mainly comes from the fact that the calvo lottery parameter on credit rates catches all the information in the data to the detriment of the elasticity of the external premium. Even if this financial friction has negligible impacts in the fit exercise, it is a key parameter in our model when studying the international transmission of the risk in the economy.

1.6 Capital Goods Producers

The capital supplier is an alternative decentralization scheme in which a new type of firms, capital producers, make the capital supply and utilization decisions.

1.6.1 Capital Supply Decisions

The suppliers of capitals lend capital to the intermediate firms, once it is financed by the entrepreneurs. Capital suppliers are homogeneous and distributed over a continuum normalized to one. The representative capital supplier k acts competitively to supply a quantity of capital $K_{i,t+1}(k)$ to intermediate firms and invest a quantity of final goods $I_{i,t}(k)$ to keep it productive. We assume that it is is costly to invest, *i.e.* it has to pay an adjustment cost on investment:

$$AC_{i,t}^{I}(k)=\chi_{i}^{I}\left(\frac{e^{\varepsilon_{i,t}^{I}}I_{i,t}(k)}{I_{i,t-1}(k)}-1\right)^{2} \tag{A.22}$$

where χ_i^I is the adjustment cost. Thus the capital stock of the representative capital supplier evolves according to:

$$K_{i,t+1}(k) = \left(1 - AC_{i,t}^I(k)\right) I_{i,t}(k) + (1-\delta) K_{i,t}(k) \tag{A.23}$$

The capital producer produces the new capital stock $Q_{i,t}K_{i,t+1}(k)$ by buying the deprecated capital and investment goods. The project of the representative supplier thus writes:

$$\Pi_{i,t}^k(k) = Q_{i,t}K_{i,t+1}(k) - (1-\delta) Q_{i,t}K_{i,t}(k) - P_{i,t}^I I_{i,t}(k), \tag{A.24}$$

Replacing Equation A.23 in Equation A.24, the representative capital supplier chooses $I_{i,t}(k)$ to maximize profits:

$$\max_{\{I_{i,t}(k)\}} \mathbb{E}_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \beta^\tau \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \Pi_{t+\tau}^k(k) \right\},$$

where $\beta^\tau \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c}$ is the household subjective discount factor. The price of capital renting thus solves:

$$Q_{i,t} = P_{i,t}^I + Q_{i,t}\frac{\partial\left(I_{i,t}(k)\, AC_{i,t}^I(k)\right)}{\partial I_{i,t}(k)} + \beta \mathbb{E}_t \frac{\lambda_{i,t+1}^c}{\lambda_{i,t}^c} Q_{i,t+1}\frac{\partial\left(I_{i,t+1}(k)\, AC_{i,t+1}^I(k)\right)}{\partial I_{i,t}(k)}. \tag{A.25}$$

Ignoring investment adjustment costs in this last expression (*i.e.* imposing $\chi^I = 0$), we simply get, $Q_{i,t} = P_{i,t}^I$. $Q_{i,t}$ stands for the asset price given the adjustment costs on investment production function. The derivatives of $AC_{i,t}^I$ in $I_{i,t}$ are:

$$\frac{\partial\left[I_{i,t}AC_{i,t}^I\right]}{\partial I_{i,t}} = \frac{\chi_i^I}{2}\left(3\left(\frac{e^{\varepsilon_{i,t}^I} I_{i,t}}{I_{i,t-1}}\right)^2 + 1 - 4\frac{e^{\varepsilon_{i,t}^I} I_{i,t}}{I_{i,t-1}}\right),$$

$$\frac{\partial\left[I_{i,t+1}AC_{i,t+1}^I\right]}{\partial I_{i,t}} = \chi_i^I\left(\left(e^{\varepsilon_{i,t+1}^I}\frac{I_{i,t+1}}{I_{i,t}}\right)^2 - \left(e^{\varepsilon_{i,t+1}^I}\frac{I_{i,t+1}}{I_{i,t+1}}\right)^3\right).$$

As underlined by Figure A.8, we compare up to five different indicators to assess how well investment adjustment cost improve the model results in matching capital cycles with the business cycles. First, adjustment costs on investment dampen the response to both supply and demand shocks (figure a and b). These costs also adjust the theoretical variance of investment growth to the empirical variance observed in the data (figure c). Turning to the autocorrelations, we see that the model performs well at replicating the observed autocorrelation up to two lags (figure d). We find similar results for the correlation between output and investment growths (figure e).

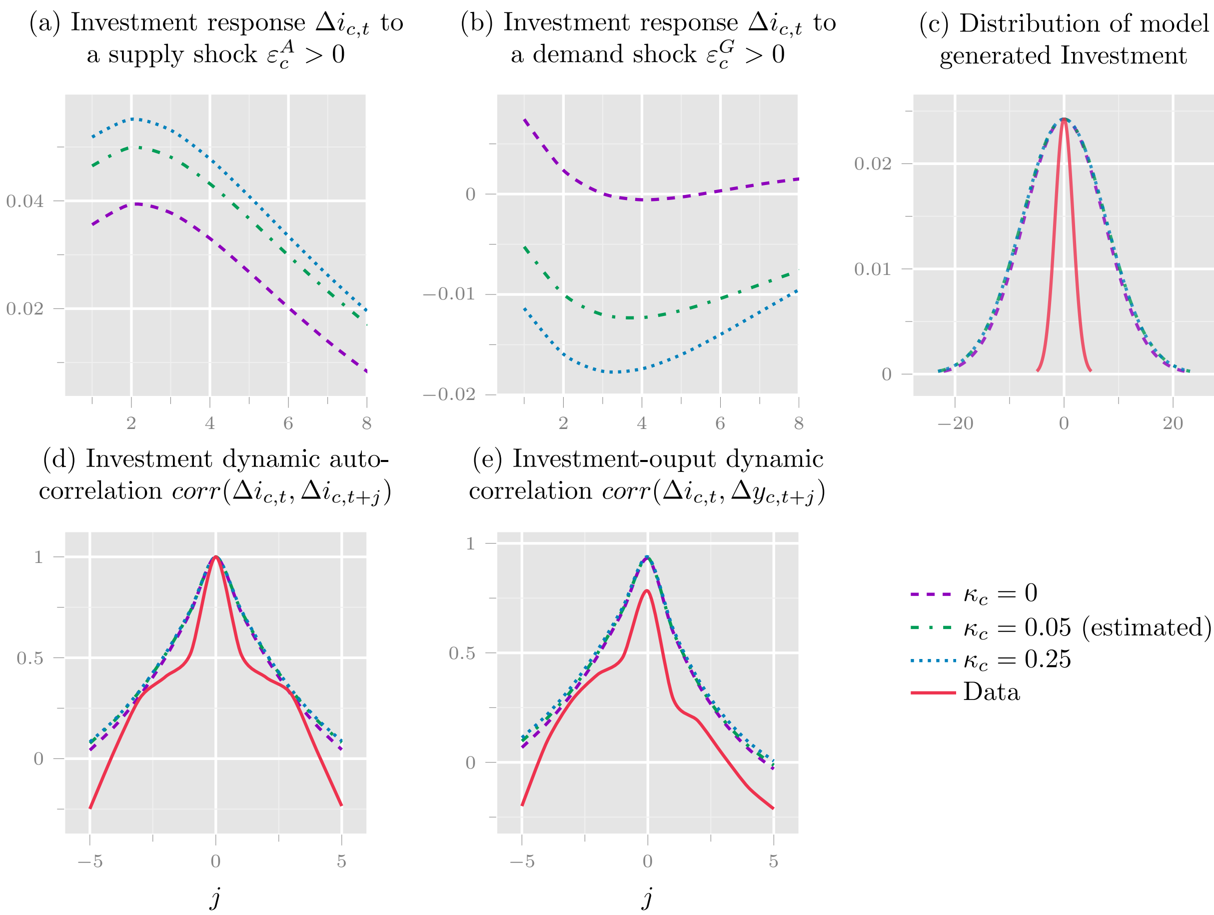


FIGURE A.7: The role of the financial accelerator in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

1.6.2 The Rentability of one Unit of Capital

The return of holding one unit of capital from $t-1$ to t is determined by:

$$\mathbb{E}_{t-1}\left(1+r_{i,t}^{k}\right)=\frac{Z_{i,t}+(1-\delta)\,Q_{i,t}}{Q_{i,t-1}}. \tag{A.26}$$

Equation A.26 takes into account the assumption that households make the capital accumulation. The capital supplier is actually an alternative decentralization scheme in which firms make the capital supply decisions. To get the equation of the *ex post* rentability of one unit of capital, we must suppose that the household supplies capital by investing $P_{i,t}^{I}I_{i,t}(j)$ and earning revenues from renting capital $Z_{i,t}K_{i,t}(j)$. Maximizing utility under capital accumulation constraint (Equation A.23), the FOCs write:

$$\begin{aligned}
&(\partial B_{i,t+1}(j)):\mathbb{E}_{t}\left\{\frac{e^{\varepsilon_{i,t}^{U}}\lambda_{i,t}^{c}}{e^{\varepsilon_{i,t+1}^{U}}\lambda_{i,t+1}^{c}}\frac{P_{i,t+1}^{C}}{P_{i,t}^{C}}\right\}=\frac{\beta\left(1+r_{i,t}^{D}\right)}{1+AC_{i,t}^{D\prime}(j)},\\
&(\partial K_{i,t+1}(j)):\lambda_{i,t}^{k}+\beta\mathbb{E}_{t}\lambda_{i,t+1}^{c}\left[P_{i,t+1}\Phi(u_{i,t+1})-Z_{i,t+1}u_{i,t+1}\right]-\beta(1-\delta)\,\mathbb{E}_{t}\lambda_{i,t+1}^{k},
\end{aligned}$$

where $\lambda_{i,t}^{c}$ ($\lambda_{i,t}^{k}$) is the Lagrangian multiplier on the budget constraint (capital accumulation constraint). Tobin's Q is defined by $Q_{t}=\lambda_{i,t}^{k}/\lambda_{i,t}^{c}$, then replacing in the FOC $(\partial K_{i,t+1}(j))$:

$$Q_{i,t}=\beta\frac{\lambda_{i,t+1}^{c}}{\lambda_{i,t}^{c}}\left[Z_{i,t+1}u_{i,t+1}-P_{i,t+1}\Phi(u_{i,t+1})+Q_{i,t+1}(1-\delta)\right].$$

Combining the previous equation with FOC $\left(\partial D_{i,t+1}^{d}(j)\right)$ leads to the no arbitrage condition between deposits and capital assets:

$$\frac{1+r_{i,t}^{D}}{1+AC_{i,t}^{D\prime}(j)}=\mathbb{E}_{t}\frac{\left[Z_{i,t+1}u_{i,t+1}-P_{i,t+1}\Phi(u_{i,t+1})+Q_{i,t+1}(1-\delta)\right]}{Q_{i,t}}\frac{e^{\varepsilon_{i,t}^{U}}}{e^{\varepsilon_{i,t+1}^{U}}}.$$

Following Bernanke et al. (1999) we lag the previous equation and replace r_{t+1}^{D} by $r_{i,t+1}^{k}$ to get the *ex post return* of capital. Since capital supply decisions are decentralized, we suppose that they are independent of preference shocks, we apply the same hypothesis for adjustment costs on deposits.

1.6.3 Capital Utilization Decisions

As in Smets & Wouters (2003, 2007), we assume that capital requires one period to be settled so that:

$$K_{i,t+1}^{u}=u_{i,t}K_{i,t}, \tag{A.27}$$

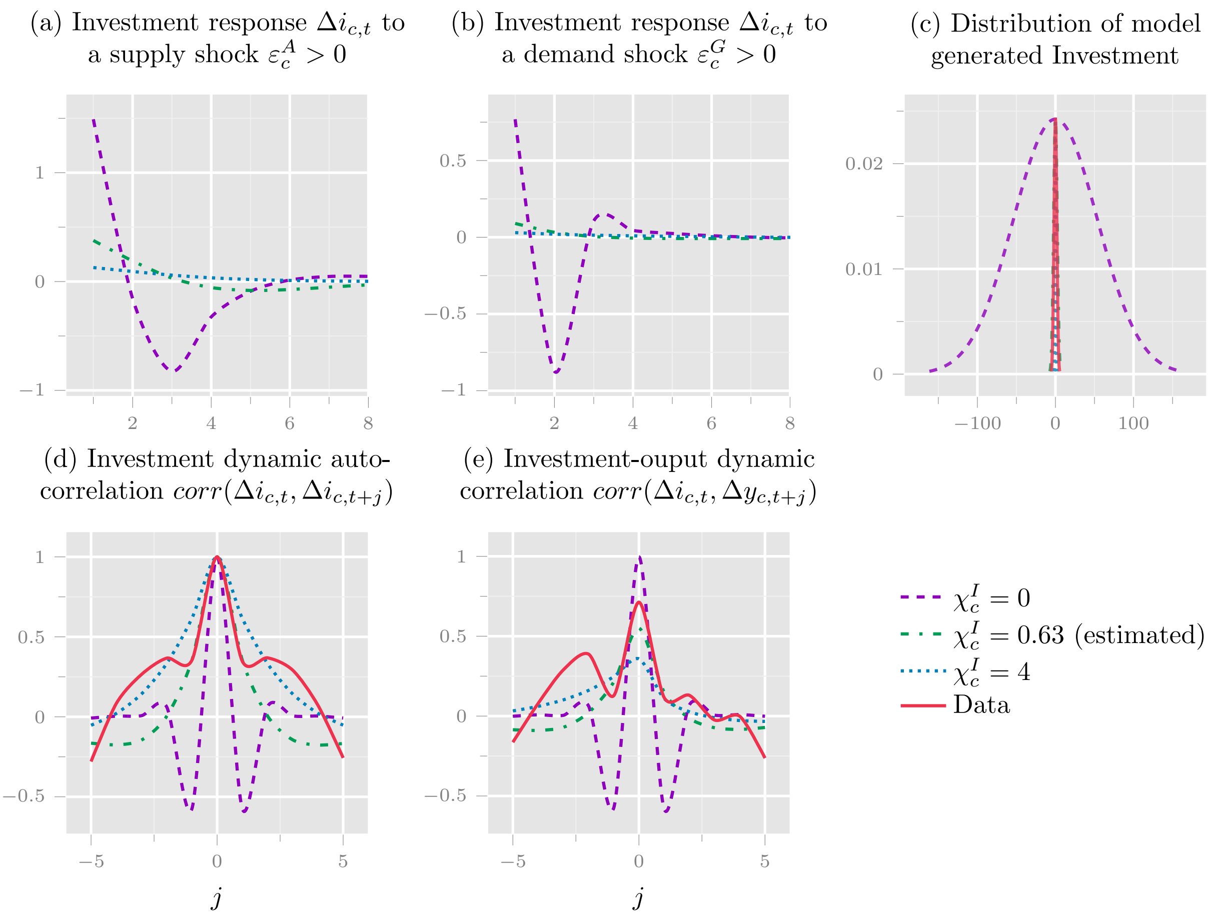


FIGURE A.8: The role of investment adjustment costs in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

given a level of capital utilization of capital $u_{i,t}$. The total amount of capital services in the production function is $u_{i,t}K_{i,t}$, total revenues from renting capital are $Z_{i,t}u_{i,t}K_{i,t}$. The benefit of increased utilization must be weighted against utilization costs, expressed by $\Phi(u_{i,t})K_{i,t}$. We defined the capital utilization cost function via:

$$\Phi(u_{i,t}) = \bar{Z}(u_{i,t}-1) + \bar{Z}\frac{\psi_i}{2}(u_{i,t}-1)^2 .$$

This relationship is determined by:

$$\max_{u_{i,t}} Z_{i,t}u_{i,t}K_{i,t} - \Phi(u_{i,t})K_{i,t}.$$

The first order condition writes:

$$Z_{i,t} = \Phi'(u_{i,t}),$$

taken in logs:

$$\hat{z}_{i,t} \simeq \frac{\psi_i}{1-\psi_i}\hat{u}_{i,t}, \tag{A.28}$$

where $\psi_i \in [0,1]$ is the elasticity of utilization costs with respect to capital inputs.

In Figure A.9, we plot alternative indicators to show why variable capital utilization is helpful in explaining business cycles. As reported, we see that this variable capital utilization has almost no effect on both supply and demand shocks and on dynamic auto-correlations. The only sensible result concerns the fitting of the distribution of observed versus model generated data. We include this real friction in chapter 2, 4 and 5.

1.7 The Banking Sector

This sector is made up of two distinct branches: a continuum of monopolistic commercial banks and a financial intermediary. Monopolistic banks b provide different types of loans and deposit services and set interest rate in a Calvo basis. The financial intermediary is a CES packer, he produces one homogenous loan and deposit service using the different varieties from banks. Banks may engage in cross-border loans but deposit system remain closed.

1.7.1 The Financial Intermediary (CES Packer)

The financial intermediary has deposit and loan activities, it acts as a loan and deposit bundler in a perfectly competitive market. Wholesale branches supply differentiated types b of deposits and loans packed by retail branches. It maximizes profits subject to

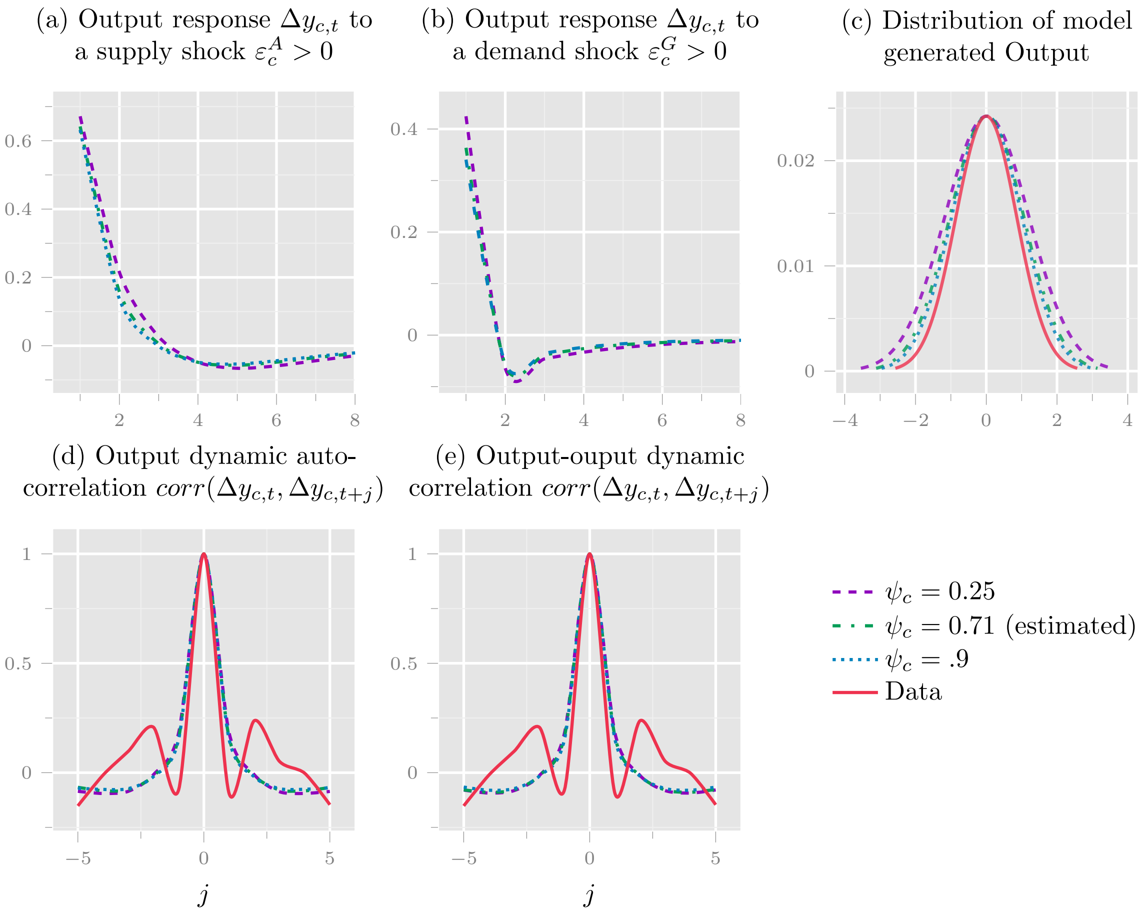


FIGURE A.9: The role of variable capital utilization in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

the supply curve:

$$
\begin{aligned}
\max_{D_{i,t+1}(b),L^s_{i,t}(b)} r^D_{i,t} D^d_{i,t+1} + r^L_{i,t} L^d_{i,t+1} - \mathcal{G}\left(r^D_{i,t}(b)\, D_{i,t+1}(b)\right) + \mathcal{G}\left(r^L_{i,t}(b)\, L^s_{i,t+1}(b)\right) \\
s.t.\ \ D^d_{i,t+1} = \left[\left(\frac{1}{n_i}\right)^{\frac{1}{\epsilon_D}} \mathcal{G}\left(D_{i,t+1}(b)^{\frac{(\epsilon_D-1)}{\epsilon_D}}\right)\right]^{\frac{\epsilon_D}{(\epsilon_D-1)}} \\
s.t.\ \ L^d_{i,t+1} = \left[\left(\frac{1}{n_i}\right)^{\frac{1}{\epsilon_L}} \mathcal{G}\left(L^s_{i,t+1}(b)^{\frac{(\epsilon_L-1)}{\epsilon_L}}\right)^{\frac{\epsilon_L}{(\epsilon_L-1)}}\right]
\end{aligned}
$$

Where $L^d_{i,t+1}$ is the loans demand from home and foreign entrepreneurs and $\mathcal{G}(.)$ is the aggregator function. Deposits and loans are imperfect substitute with elasticity of substitution $\epsilon_D < -1$ and $\epsilon_L > 1$. We find the intermediate demand functions associated from the previous problem are:

$$
D_{i,t+1}(b) = \frac{1}{n_i}\left(\frac{r^D_{i,t}(b)}{r^D_{i,t}}\right)^{-\epsilon_D} D^d_{i,t+1}, \qquad \forall b, \tag{A.29}
$$

and:

$$
L^s_{i,t+1}(b) = \frac{1}{n_i}\left(\frac{r^L_{i,t}(b)}{r^L_{i,t}}\right)^{-\epsilon_L} L^d_{i,t+1}, \qquad \forall b. \tag{A.30}
$$

Thus the aggregate price index of all varieties in the economy writes,

$$
r^D_{i,t} = \left[\frac{1}{n_i}\mathcal{G}\left(r^D_{i,t}(b)^{1-\epsilon_D}\right)\right]^{\frac{1}{1-\epsilon_D}}, \tag{A.31}
$$

$$
r^L_{i,t} = \left[\frac{1}{n_i}\mathcal{G}\left(r^L_{i,t}(b)^{1-\epsilon_L}\right)\right]^{\frac{1}{1-\epsilon_L}}. \tag{A.32}
$$

1.7.2 The Commercial Bank

In each country, the banking sector finances investment projects to home and foreign entrepreneurs by supplying one-period loans. The banking system is heterogenous with regard to liquidity, and banks engage in interbank lending at the national and international levels. Thus, cross-border loans are made of corporate loans (between banks and entrepreneurs) and interbank loans.

To introduce an interbank market, we suppose that the banking system combines liquid and illiquid banks. We assume that a share of banks λ are illiquid *(i.e.* credit constrained), while the remaining banks share $1-\lambda$ are liquid and supply loans to entrepreneurs and to illiquid banks. We assume that a liquid bank is characterized by her direct accessibility to the ECB fundings. Conversely, an illiquid bank does not have access to the ECB fundings. This assumption is empirically motivated: in the Eurosystem, only a fraction of the 2500 banks participates regularly to the bidding process in main refinancing operations of the ECB while the others rely on interbank funding, as underlined by Gray et al. (2008). Extending this assumption in an international perspective, illiquid banks can borrow from both domestic and foreign liquid banks, which gives rise to cross-border interbank lending flows.

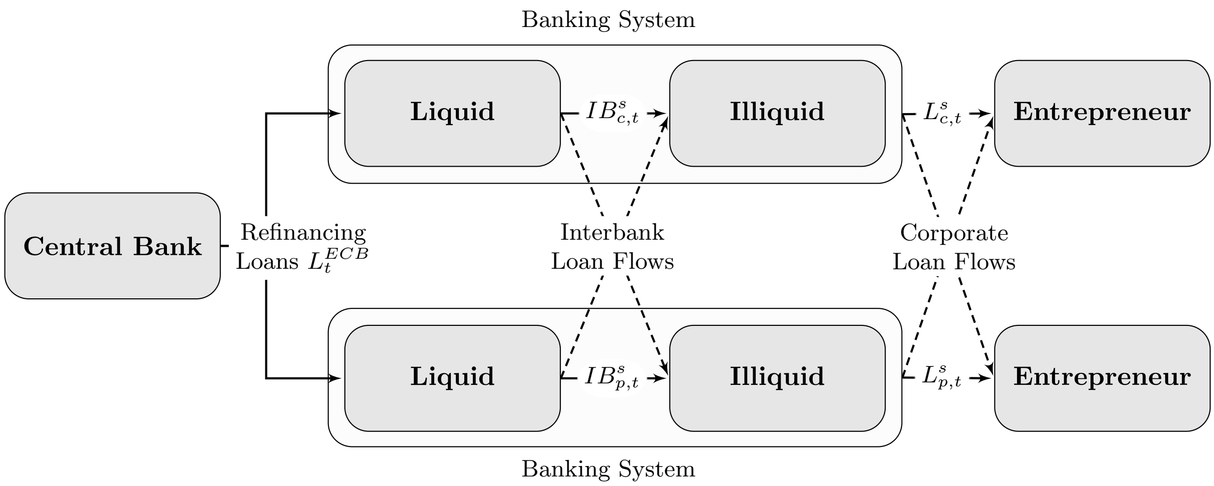


FIGURE A.10: Implementing the interbank market in a New Keynesian Framework

Illiquid Banks The representative share λ of illiquid bank b in country i operates under monopolistic competition to provide a quantity of loans $L^s_{i,t+1}(b)$ to entrepreneurs that is financed by deposits $D_{i,t+1}(b)$ from households, interbank loans $IB_{i,t+1}(b)$ from the interbank market (with a one-period maturity) at a rate $P^{IB}_{i,t}$. The balance sheet of the bank writes:

$$L^s_{i,t+1}(b) = IB^{\mathcal{H}}_{i,t+1}(b) + BK_{i,t+1}(b) + liab_{i,t}(b), \tag{A.33}$$

where $L^s_{i,t+1}(b)$ is the loan supply of borrowing banks, $IB^{\mathcal{H}}_{i,t+1}(b)$ is the interbank loans supplied by liquid banks subject to external habits, $BK_{i,t+1}(b)$ is the bank capital and $liab_{i,t}(b)$ are other liabilities in the balance sheet of the bank that are not considered in the model[6], to close the model, we assume that the cost of these liabilities is decided by the central bank. We suppose that the demand for interbank funds are subject to external habits at a degree h^B_i where $IB^{\mathcal{H}}_{i,t+1}(b) = IB^d_{i,t+1}(b) - h^B_i(IB^d_{i,t+1} - \overline{IB}^d_i)$. These

[6]We suppose that they follow an exogenous $AR(1)$ shock process $\varepsilon^B_{i,t}$ such that, $liab_{i,t} = e^{\varepsilon^B_{i,t}}\overline{liab}_i$, this shock captures some aggregate movements in the funding constraint of banks.

habits are deemed necessary to catch-up the autocorrelation observed in the supply of loans[7].

This bank engages in international corporate loans. In this setting, we assume that there is no discrimination between borrowers, so that the representative and risk-neutral bank serves both domestic and foreign entrepreneurs without taking into account specificities regarding the national viability of projects. Under this assumption, bank default expectation regarding entrepreneurs' projects is defined by a geometric average:

$$\eta_{i,t} = \eta_{i,t}^{E} \left(\frac{\eta_{i,t}^{E}}{\overline{\overline{\eta}}}\right)^{-\alpha_i^L} \left(\frac{\eta_{j,t}^{E}}{\overline{\eta}}\right)^{\alpha_j^L}, \ \forall i \neq j \in \{c,p\}, \tag{A.34}$$

where $\eta_{i,t+1}^{E}$is the default rate in country $i \in \{c,p\}$ of entrepreneurs and $\left(1-\alpha_i^L\right)$ measures the home bias in corporate loan distribution and $\overline{\overline{\eta}}$ is the steady state level share of profitable projects[8]. The profits of the representative illiquid bank are:

$$\mathbb{E}_t \Pi_{i,t+1}^{ill}(b) = \underbrace{\left[\mathbb{E}_t \eta_{i,t+1} + \left(1-\mu^B\right)\left(1-\eta_{i,t+1}\right)\right]\left(1+r_{i,t}^L(b)\right)L_{i,t+1}^s(b)}_{\text{Revenues from loan supply activities}} - \underbrace{\left(1+r_{i,t}^D(b)\right)D_{i,t+1}(b)}_{\text{Deposit cost}} \tag{A.35}$$

$$-\underbrace{\left(1+p_{i,t}^{IB}\right)IB_{i,t+1}^d(b)}_{\text{Interbank cost}} - \underbrace{\left(1+r_t\right)liab_{i,t}(b)}_{\text{exogenous funds cost}} - \underbrace{F_i\left(\frac{L_{i,t+1}^s(b)}{BK_{i,t+1}^{ill}(b)}\right)BK_{i,t+1}^{ill}(b)}_{\text{Basel I capital requirements}},$$

where $\mu^B \in [0,1]$ denotes the loss-given-default, *i.e.* the percentage of the amount owed on a defaulted loan that the bank is not able to recover and $F_i(\cdot)$ denotes the basel I-like capital requirement penalty function paid in terms of bank capital and reads as in Gerali et al. (2010),

$$F_i(x_t) = 0.5\chi_i^{KR}\left(x_t - \bar{x}\right)^2$$

where χ_i^{KR} is the estimated size of the penalty cost function. Thus, the marginal cost of one unit of corporate loan $MC_{i,t}^{ill}(b)$ provided by the illiquid bank is the solution of the expected profit $\mathbb{E}_t \Pi_{i,t+1}^{ill}(b)$ optimization problem:

$$\max_{L_{i,t+1}^s(b), IB_{i,t+1}^d(b)} \mathbb{E}_t \Pi_{i,t+1}^{ill}(b) \tag{A.36}$$

[7]In the fit exercise, DSGE models with banking are estimated on the outstanding amount of loans contracted in the economy. Since DSGE models only include one-period maturity loans, external habits are a tractable way to catch up the high persistence in the loan contracts without modifying the steady state. Guerrieri et al. (2012) develops a similar financial friction in the borrowing constraint of entrepreneurs.

[8]We divide respectively $\eta_{i,t}^{E}$ and $\eta_{j,t}^{E}$ by $\overline{\overline{\eta}}$ to have a symmetric steady state such that $\bar{\eta}_i^E = \bar{\eta}_c = \bar{\eta}_p$, this hypothesis is neutral on the log-linear version of the model.

We assume that rates are sticky as Darracq-Pariès et al. (2011), banks must solve a two-stage problem. In the first stage, banks choose the optimal supply of credit and deposit services in a perfectly competitive input markets. The marginal cost of one unit of loan, denoted $MC_{i,t}^{ill}(b)$, is the same across illiquid banks and writes:

$$1 + MC_{i,t}^{ill}(b) = 1 + MC_{i,t}^{ill} = \frac{1 + p_{i,t}^{IB} + F_{i,t}^{L\prime}}{\mathbb{E}_t \eta_{i,t+1}}, \tag{A.37}$$

so that each bank decides the size of the spread depending on the expected failure rate of its customers $\mathbb{E}_t \eta_{i,t+1}$, the interbank rate in the economy and the penalty costs when bank capital to asset ratio deviate from its steady state[9]. The bank has access to domestic and foreign interbank loans to meet its balance sheet. The total amount borrowed by the representative bank writes:

$$IB_{i,t+1}^{d}(b) = \left(\left(1-\alpha_i^{IB}\right)^{1/\xi} IB_{h,i,t+1}^{d}(b)^{(\xi-1)/\xi} + \left(\alpha_i^{IB}\right)^{1/\xi} IB_{f,i,t+1}^{d}(b)^{(\xi-1)/\xi}\right)^{\xi/(\xi-1)}, \tag{A.38}$$

where parameter ξ is the elasticity of substitution between domestic and foreign interbank funds, α_i^{IB} represents the percentage of cross-border interbank loan flows in the monetary union and $IB_{h,i,t+1}^{d}(b)$ (resp. $IB_{f,i,t+1}^{d}(b)$) the amount of domestic (resp. foreign) loans demanded by borrowing bank b in country i. The total cost incurred by illiquid banks to finance interbank loans, $1 + P_{i,t}^{IB}$, is thus defined according to the CES aggregator:

$$1 + p_{i,t}^{IB} = \left(\left(1-\alpha_i^{IB}\right)\left(1 + r_{h,t}^{IB}\right)^{1-\xi} + \alpha_i^{IB}\left(1 + r_{f,t}^{IB}\right)^{1-\xi}\right)^{1/(1-\xi)}, \tag{A.39}$$

where $1 + r_{h,t}^{IB}$ (resp. $1 + r_{f,t}^{IB}$) is the cost of loans obtained from home (resp. foreign) banks in country i. The decision to borrow from a particular bank is undertaken on the basis of relative interbank national interest rates:

$$IB_{h,i,t+1}^{d}(b) = \left(1-\alpha_i^{IB}\right)\left[\frac{1 + r_{h,t}^{IB}}{1 + p_{i,t}^{IB}}\right]^{-\xi} IB_{i,t+1}^{d}(b), \text{ and } IB_{f,i,t+1}^{d}(b) = \alpha_i^{IB}\left[\frac{1 + r_{f,t}^{IB}}{1 + p_{i,t}^{IB}}\right]^{-\xi} IB_{i,t+1}^{d}(b).$$

Here, cross-border lending is measured through the values undertaken by $IB_{h,i,t+1}^{d}(b)$, (*i.e.*, interbank loans contracted by liquid foreign banks from domestic overliquid banks). Finally following Hirakata et al. (2009), the bank capital accumulation process of illiquid banks ($BK_{i,t+1}^{ill}(b)$) is determined by:

$$BK_{i,t+1}^{ill}(b) = \left(1 - \tau_i^{ill}\right)\Pi_{i,t}^{ill}(b), \tag{A.40}$$

where τ_i^{ill} is a proportional tax on the profits of the bank.

[9] $F_{i,t}^{L\prime}$ denotes the derivate in $L_{i,t+1}^{s}(b)$ of the capital requirement cost function $F_i(\cdot)$.

Liquid Banks The representative share of $1-\lambda$ liquid bank b in country i operates under monopolistic competition to provide a quantity of loans $L^s_{i,t+1}(b)$ to entrepreneurs. It also provides a quantity of interbank loans $IB^s_{i,t+1}(b)$ to illiquid banks. We suppose that the intermediation process between liquid and illiquid banks is costly: we introduce a convex monitoring technology *à la* Cúrdia & Woodford (2010) and Dib (2010) with a functional form $AC^{IB}_{i,t+1}(b) = \frac{\chi^{IB}_i}{2}\left(IB^s_{i,t+1}(b) - \overline{IB}^s_i(b)\right)^2$ where parameter χ^{IB}_i is the level of financial frictions between liquid banks in country i and home and foreign illiquid banks[10]. Loans created by the liquid bank are financed by one-period maturity loans from the central bank $(L^{ECB}_{i,t+1}(b))$ at the refinancing interest rate R_t. Finally, the bank's balance sheet is defined by:

$$L^s_{i,t+1}(b) + IB^s_{i,t+1}(b) = L^{ECB}_{i,t+1}(b) + BK_{i,t+1}(b) + D_{i,t} + liab_{i,t}(b).$$

According to the behavior of illiquid banks, we assume that there is no discrimination between borrowers. The one-period profit of the bank is determined by:

$$\begin{aligned}\Pi^{liq}_{i,t}(b) = {} & \left(1-\mu^B\mathbb{E}_t\eta_{i,t+1}\right)\left(1+r^L_{i,t}(b)\right)L^s_{i,t+1}(b) + \left(1+r^{IB}_{i,t}(b)\right)IB^s_{i,t+1}(b)\\ & - (1+r_t)\,L^{ECB}_{i,t+1}(b) - AC^{IB}_{i,t+1}(b)\,(1+r_t)\,liab_{i,t}(b)\\ & - F_i\left(\frac{L^s_{i,t+1}(b) + IB^s_{i,t+1}(b)}{BK^{liq}_{i,t+1}(b)}\right)BK^{liq}_{i,t+1}(b).\end{aligned}$$

The representative bank solves he profit maximization problem:

$$\max_{L^s_{i,t+1}(b), IB^s_{i,t+1}(b), L^{ECB}_{i,t+1}(b)} \Pi^{liq}_{i,t}(b), \tag{A.41}$$

under the balance sheet constraint. The marginal cost of one unit of loan $MC^{liq}_{i,t}(b)$ that solves the maximization problem is:

$$1 + MC^{liq}_{i,t}(b) = 1 + MC^{liq}_{i,t} = \frac{1 + r_t + F^{L\prime}_{i,t}}{\mathbb{E}_t\eta_{i,t+1}}. \tag{A.42}$$

Similarly to the illiquid bank, bank capital evolves according to Equation A.40, such that,

$$BK^{liq}_{i,t+1}(b) = \left(1-\tau^{liq}_i\right)\Pi^{liq}_{i,t}(b).$$

There are two interest rates to be determined: the interest rate on the interbank market and the interest rate on corporate loans. First, on a perfectly competitive market, the

[10] Contrary to Cúrdia & Woodford (2010) but in the same vein of Dib (2010), the monitoring technology does not alter the steady state of the model to keep the estimation of χ^{IB}_i as simple as possible. Several papers refer to monitoring technology functions in the intermediation process of banks, see for example Goodfriend & McCallum (2007) or Casares & Poutineau (2011).

interbank rate in country i is determined from the problem in Equation A.41:

$$1+r_{i,t}^{IB}\left(b\right)=\chi_{i}^{B}\left(IB_{i,t+1}\left(b\right)-\overline{IB}_{i}^{s}\left(b\right)\right)+\left(1+r_{t}\right)+F_{i,t}^{IB\prime}, \tag{A.43}$$

where χ_{i}^{B} is a cost parameter, $IB_{i,t+1}^{s}\left(b\right)$ is the amount of interbank loans contracted in period t with a one period maturity and $\overline{IB}_{i}^{s}\left(b\right)$ is the steady state value of interbank loans.

In Figure A.11, we plot some indicators to understand how the introduction of an heterogenous banking system is an important feature that drives the credit cycles of a monetary union. First, we see that this friction has a procyclical effect on the volatility of the supply of interbank loans: the more illiquid is the banking system, the more it is volatile. Under this setting, this friction allows us to fit the artificial standard deviation of the interbank loan supply to its empirical counterpart as underlined by Figure A.11.c. This friction also slightly helps in catching up the dynamic correlation with output and its autocorrelation.

The loan supply decisions In the second stage problem solved by banks, the interest rate charged by banks of country i on corporate loans accounts for the liquidity of the national banking system. Anticipating over symmetric issues at the equilibrium to improve the tractability of the model, we assume that all banks belonging to a national banking system share the same marginal cost of production, reflecting the average liquidity degree of national banks. Aggregate marginal cost $MC_{i,t}^{L}$ combines outputs from liquid and illiquid banks of country i according to[11]:

$$1+MC_{i,t}^{L}=\left(1+MC_{i,t}^{ill}\right)^{\lambda}\left(1+MC_{i,t}^{liq}\right)^{(1-\lambda)}. \tag{A.44}$$

Under Calvo pricing, banks operates under monopolistic competition and sets the interest rate on loans contracted by entrepreneurs on a staggered basis as in Darracq-Pariès et al. (2011). A fraction θ_{i}^{L} of banks is not allowed to optimally set the credit rate such that, $r_{i,t}^{L}\left(b\right)=r_{i,t-1}^{L}\left(b\right)$. Assuming that it is able to modify its loan interest rate with a constant probability $1-\theta_{i}^{L}$, it chooses $r_{i,t}^{L*}\left(b\right)$ to maximize its expected sum of profits $\Pi_{i,t}^{L}\left(b\right)$:

$$\max_{\left\{R_{i,t}^{L*}(b)\right\}} E_{t}\left\{\sum\nolimits_{\tau=0}^{\infty}\left(\theta_{i}^{L}\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\left[r_{i,t}^{L*}\left(b\right)-MC_{i,t+\tau}^{L}\right]L_{i,t+1+\tau}^{s}\left(b\right)\right\}, \tag{A.45}$$

[11]We borrow this aggregation procedure from the solution introduced by Gerali et al. (2010), to aggregate borrowing and saving households labor supply.

subject to the demand constraint from retail banks:

$$L^{s}_{i,t+1+\tau}(b) = \left(\frac{r^{L*}_{i,t}(b)}{r^{L}_{i,t+\tau}}\right)^{-\epsilon_L} L^{d}_{i,t+1+\tau}, \qquad \tau > 0, \tag{A.46}$$

where $L^{s}_{i,t+1}$ represents the quantity of the loans produced in country i, $\lambda^{c}_{i,t}$ is the household marginal utility of consumption.

Finally, the first order condition writes:

$$\sum\nolimits_{\tau=0}^{\infty} \left(\theta^{L}_{i}\beta\right)^{\tau} \frac{\lambda^{c}_{i,t+\tau}}{\lambda^{c}_{i,t}} \left[r^{L*}_{i,t}(b) - \frac{\epsilon_L}{(\epsilon_L - 1)} e^{\gamma^{L}_{i}\varepsilon^{L}_{i,t+\tau}} MC^{L}_{i,t+\tau}\right] L_{i,t+1+\tau}(b) = 0, \tag{A.47}$$

where $\varepsilon^{L}_{i,t}$ is an *ad hoc* time-varying mark-up shock to the deposit rate equation and $\gamma^{L}_{i} \geq 0$ is a parameter[12].

In Figure A.12, we run different diagnostics to understand why sticky credit rates help in catching up the business cycle statistics. First, we see on figure a and b that sticky rates strongly dampen the effects of both shocks. This in turn reduces the variance of the model-generated credit rates and helps in fitting the observed distribution with the artificial one (figure c). We see that there are still very important differences between the model generated distribution and the empirical one, the difference between these distributions is absorbed exogenously by the mark-up shock $\varepsilon^{L}_{i,t}$. This suggests that some additional frictions are missing to fit well the credit rates in a new Keynesian framework. Finally, the interest rate stickiness significantly improves the fit of the observed correlation with its artificial counterpart while it is neutral the dynamic correlation with output[13].

The deposit decisions When taking their deposit supply decisions, banks also solves a two-stages problem due to imperfect price adjustments on this market. The deposit market is very special since households supply deposits to banks, but banks decides of the remuneration of deposits. Following Gerali et al. (2010) and Darracq-Pariès et al. (2011), we suppose that the marginal cost of one unit of deposit is determined by the central bank:

$$MC^{D}_{i,t}(b) = MC^{D}_{i,t} = r_t. \tag{A.48}$$

so that each bank decides the size of the spread depending on the expected failure rate of its customers.

[12] The exogenous shock is affected by γ^{L}_{i} to normalize to unity (or very close to unity) the impact of the shock $\varepsilon^{L}_{i,t}$ in the log deviation form of the model as in Smets & Wouters (2007), such that $\gamma^{L}_{i} = \theta^{L}_{i} / \left[\left(1-\beta\theta^{L}_{i}\right)\left(1-\theta^{L}_{i}\right)\right]$.

[13] However, the model catches remarkably well the correlation with output (no lag) independently of the level of rate stickiness.

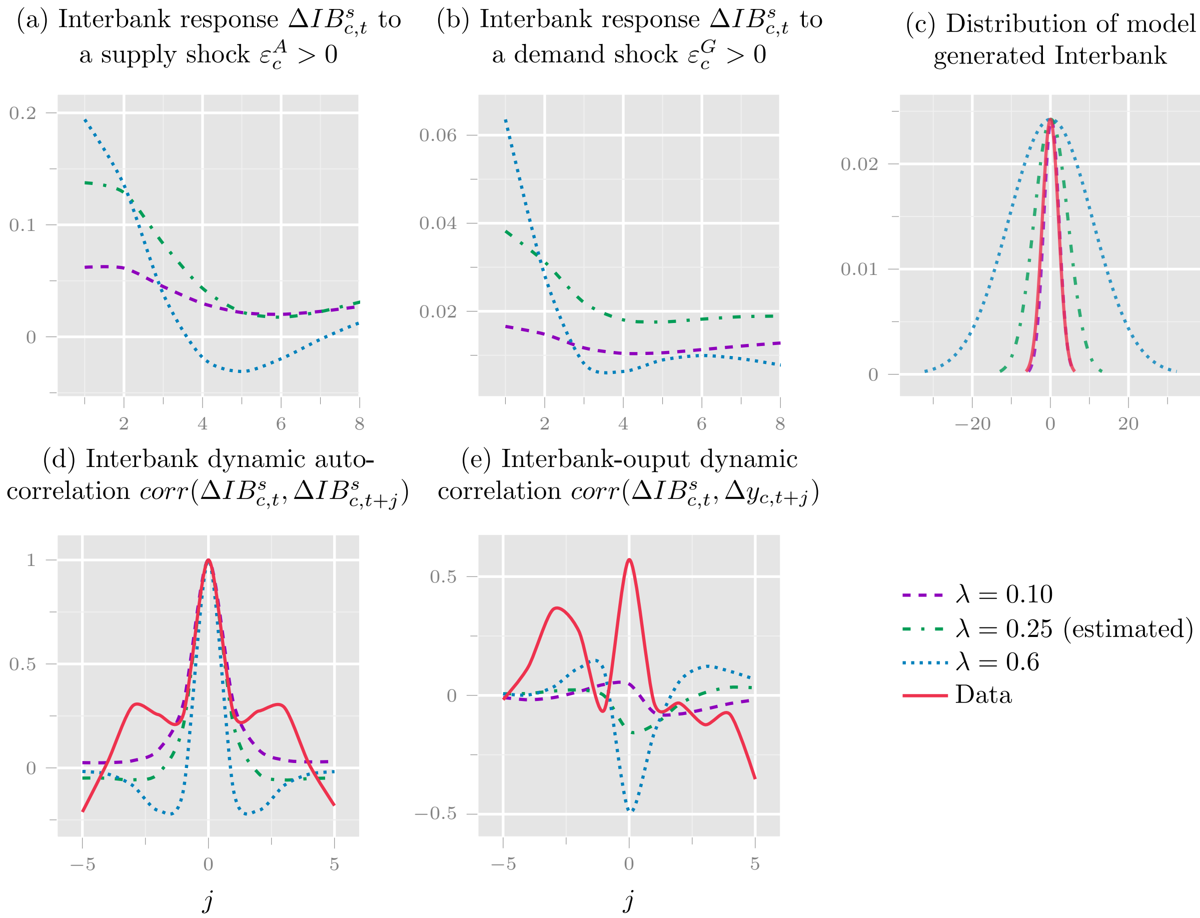


FIGURE A.11: The role of an heterogenous banking system in matching the business cycles of the Euro Area (*generated from chapter 4 model*).

Under Calvo pricing, banks sets the interest rate on deposits supplied by households on a staggered basis as in Darracq-Pariès et al. (2011). A fraction θ_i^D of banks is not allowed to optimally set the credit rate such that, $r_{i,t}^D(b) = r_{i,t-1}^D(b)$. Assuming that it is able to modify its loan interest rate with a constant probability $1-\theta_i^D$, it chooses $r_{i,t}^{D*}(b)$ to maximize its expected sum of profits $\Pi_{i,t}^D(b)$:

$$\max_{\left\{R_{i,t}^{D*}(b)\right\}} E_t \left\{ \sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^D \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[MC_{i,t+\tau}^D - r_{i,t}^{D*}(b)\right] D_{i,t+1+\tau}(b) \right\}, \tag{A.49}$$

subject to the demand constraint from retail banks:

$$D_{i,t+1+\tau}(b) = \left(\frac{r_{i,t}^{D*}(b)}{r_{i,t+\tau}^D} \right)^{-\epsilon_D} D_{i,t+1+\tau}^d, \qquad \tau > 0, \tag{A.50}$$

where $L_{i,t+1}^s$ represents the quantity of the loans produced in country i, $\lambda_{i,t}^c$ is the household marginal utility of consumption.

Finally, the first order condition writes:

$$\sum\nolimits_{\tau=0}^{\infty} \left(\theta_i^D \beta\right)^{\tau} \frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c} \left[r_{i,t}^{D*}(b) - \frac{\epsilon_D}{\epsilon_D - 1} e^{\gamma_i^D \varepsilon_{i,t}^D} MC_{i,t+\tau}^D \right] D_{i,t+1+\tau}(b) = 0 \tag{A.51}$$

where $\varepsilon_{i,t}^D$ is an *ad hoc* time-varying mark-up shock to the deposit rate equation and $\gamma_i^D \geq 0$ is a parameter[14].

Figure A.13 underlines the critical role of sticky deposit rates in fitting the data. First, deposit stickiness tends to decrease the system response to both supply and demand shocks. At a first sight, the interest rate stickiness helps in catching up the relatively low standard deviation of deposit rates (figure c), suggesting that the estimated Calvo probability is too low. However figure d shows that a high level of stickiness strongly deteriorates the auto-correlation fit with the data. As a consequence, the model considers a calvo probability that makes the model explain reasonably well both autocorrelation and distribution. Finally, the model is good at replicating the dynamic correlation with output independently the value of θ_c^D.

1.8 Authorities

National governments finance public spending by charging a proportional taxes on the net wealth of banks τ^{BK}, entrepreneurs τ^{E} and by receiving a total value of taxes

[14] The exogenous shock is affected by γ_i^D to normalize to unity (or very close to unity) the impact of the shock $\varepsilon_{i,t}^D$ in the log deviation form of the model as in Smets & Wouters (2007), such that $\gamma_i^D = \theta_i^D / \left[\left(1-\beta\theta_i^D\right)\left(1-\theta_i^D\right)\right]$.

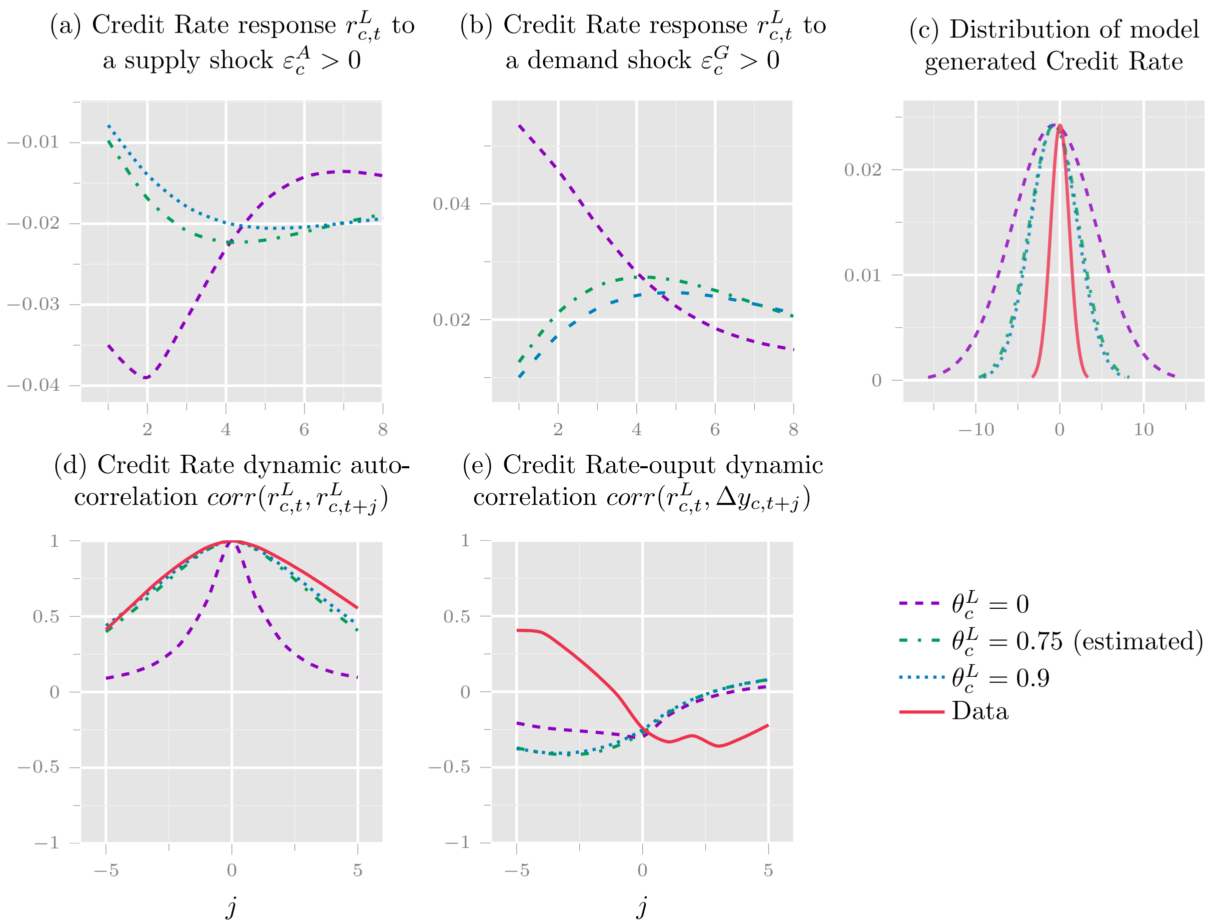


FIGURE A.12: The role of sticky credit rates in matching the business cycles of the Euro Area (*generated from chapter 5 model*).

$G(T_{i,t}(j))$ from households. The budget constraint of the national government writes:

$$\mathcal{G}(T_{i,t}(j)) + \tau^E \mathcal{G}\left(P_{i,t}^C N_{i,t}(e)\right) + \tau^{BK} \mathcal{G}\left(P_{i,t}^C BK_{i,t}(b)\right) = P_{i,t} G_{i,t}$$

$$= P_{i,t} G\left(G_{i,t}(i)^{\frac{\epsilon_P - 1}{\epsilon_P}}\right)^{\frac{\epsilon_P}{\epsilon_P - 1}} = P_{i,t} \bar{G}_i \varepsilon_{i,t}^G,$$

$G_{i,t}$ is the total amount of public spending in the i^{th} economy that follows and AR(1) shock process. The government demand for home goods writes, $G_{i,t}(i) = \left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P} G_{i,t}$.

Concerning federal monetary policy, the general expression of the interest rule implemented by the monetary union central bank writes:

$$\frac{1+r_t}{1+\bar{r}} = \left(\frac{1+r_{t-1}}{1+\bar{r}}\right)^{\rho} \left(\left(\pi_{u,t}^C\right)^{\phi^\pi} \left(\frac{Y_{u,t}}{Y_{u,t-1}}\right)^{\phi^{\Delta y}}\right)^{(1-\rho^r)} e^{\varepsilon_t^R}, \tag{A.52}$$

where ε_t^R is a monetary policy shock common to the monetary union members, ϕ^π is the inflation target parameter, $\phi^{\Delta y}$ is the GDP growth target. Recall that $\pi_{u,t}^C = \left(\pi_{c,t}^C\right)^n \left(\pi_{p,t}^C\right)^{1-n}$ and $Y_{u,t} = (Y_{c,t})^n (Y_{p,t})^{1-n}$.

1.9 Aggregation and Market Equilibrium

After (i) aggregating all agents and varieties in the economy, (ii) imposing market clearing for all markets, (iii) substituting the relevant demand functions, (iv) normalizing the total size of the monetary union $(n_c + n_p = 1)$ such that the size of the core area is n and the peripheral area size is $1-n$, we can deduct the general equilibrium conditions of the model. Now we can express the aggregation function of variable $X_t(x)$ as:

$$\mathcal{G}(X_{i,t}) = \begin{cases} \int_0^n X_{i,t}(x)\,\mathrm{d}x \text{ for } i = c \\ \int_n^1 X_{i,t}(x)\,\mathrm{d}x \text{ for } i = p \end{cases} \tag{A.53}$$

1.9.1 Goods Market

From Equation A.11, the aggregate price index of the national goods evolves according to:

$$P_{i,t}^{1-\epsilon_P} = \theta_i^P \left[P_{i,t-1}\left(\frac{P_{i,t-1}}{P_{i,t-2}}\right)^{\xi_i^P}\right]^{1-\epsilon_P} + \left(1-\theta_i^P\right)\left(P_{i,t}^*\right)^{1-\epsilon_P} \tag{A.54}$$

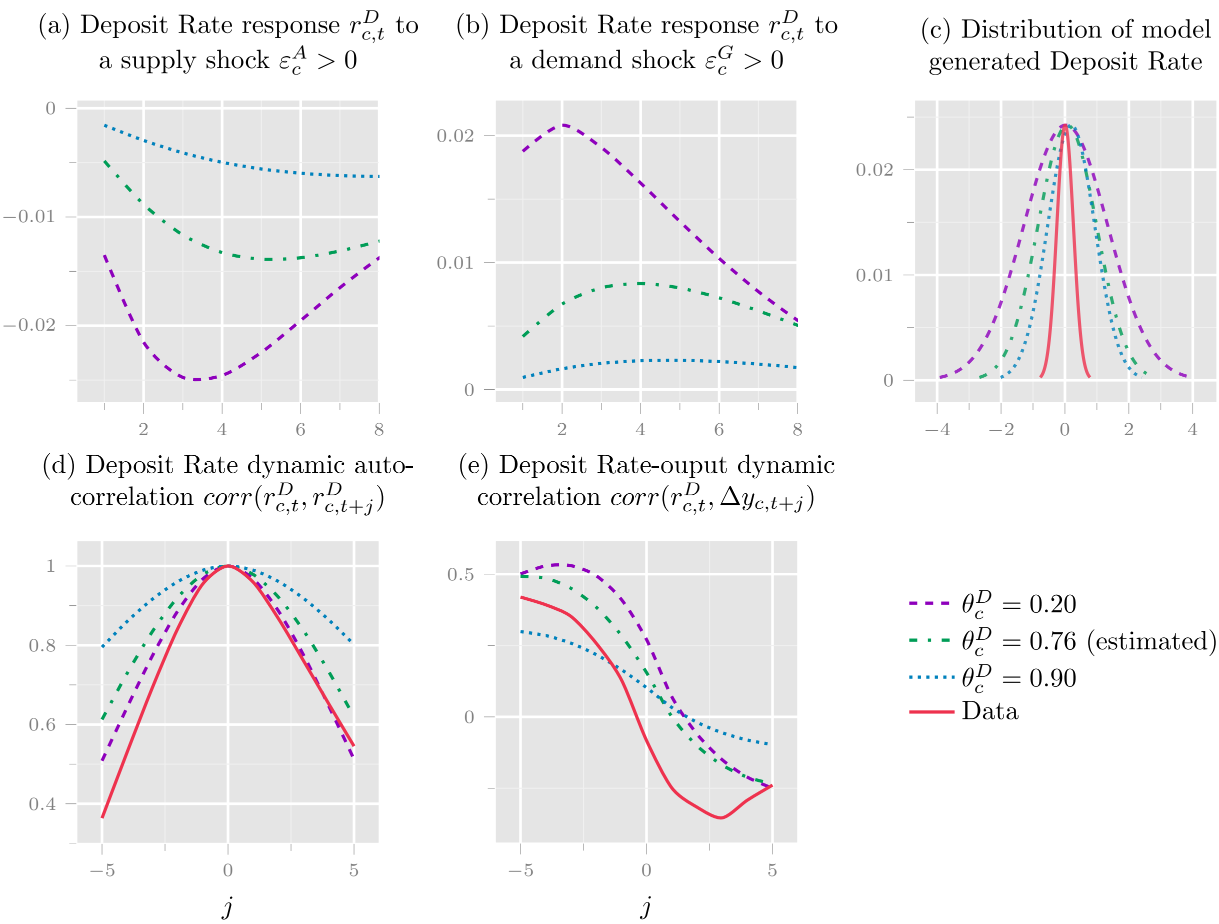


FIGURE A.13: The role of sticky deposit rates in matching the business cycles of the Euro Area (*generated from chapter 5 model*).

The equilibrium condition on the final goods market writes is defined by the aggregation of Equation A.10:

$$\mathcal{G}\left(Y_{i,t}\left(i\right)\right) = Y_{i,t}^{d}\mathcal{G}\left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P}$$

where $\mathcal{G}\left(Y_{i,t}\left(i\right)\right) = e^{\varepsilon_{i,t}^{A}}\mathcal{G}\left(K_{i,t}\left(i\right)^{\alpha} H_{i,t}^{d}\left(i\right)^{1-\alpha}\right)$ is the aggregation of intermediate goods suppliers and $Y_{i,t}^{d}$ is the resources constraint:

$$Y_{i,t}^{d} = \begin{array}{c} C_{h,i,t} + C_{f,i,t} + \left(1 + AC_{h,i,t}^{I}\right) I_{h,i,t} \\ + \left(1 + AC_{f,i,t}^{I}\right) I_{f,i,t} + G_{i,t} + AC_{i,t}^{D} \end{array}$$

Thus, replacing the demand functions of foreign and home goods (consumption and investment), we finally obtain the home final goods market equilibrium:

$$\frac{Y_{c,t}}{\Delta_{c,t}^{P}} = \left(1-\alpha_c^C\right)\left(\frac{P_{c,t}}{P_{c,t}^{C}}\right)^{-\mu} C_{c,t} + \left(1-\alpha_c^I\right)\left(\frac{P_{c,t}}{P_{c,t}^{I}}\right)^{-\mu}\left(1+AC_{c,t}^{I}\right) I_{c,t} \tag{A.55}$$

$$+\frac{n-1}{n}\left(\alpha_p^C\left(\frac{P_{c,t}}{P_{p,t}^{C}}\right)^{-\mu} C_{p,t} + \alpha_p^I\left(\frac{P_{c,t}}{P_{p,t}^{I}}\right)^{-\mu}\left(1+AC_{p,t}^{I}\right) I_{p,t}\right) \tag{A.56}$$

$$+ G_{c,t} + AC_{c,t}^{D}$$

where $\Delta_{i,t}^{P} = \mathcal{G}\left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P}$ denotes the price dispersion term, which is induced by the assumed nature of price stickiness, is inefficient and entails output loss. Since we perform a first approximation of the model, the price dispersion terms disappears. For the foreign economy:

$$\frac{Y_{p,t}}{\Delta_{p,t}^{P}} = \left(1-\alpha_p^C\right)\left(\frac{P_{p,t}}{P_{p,t}^{C}}\right)^{-\mu} C_{p,t} + \left(1-\alpha_p^I\right)\left(\frac{P_{p,t}}{P_{p,t}^{I}}\right)^{-\mu}\left(1+AC_{p,t}^{I}\right) I_{p,t} \tag{A.57}$$

$$+\frac{n}{n-1}\left(\alpha_c^C\left(\frac{P_{p,t}}{P_{c,t}^{C}}\right)^{-\mu} C_{c,t} + \alpha_c^I\left(\frac{P_{p,t}}{P_{c,t}^{I}}\right)^{-\mu}\left(1+AC_{c,t}^{I}\right) I_{c,t}\right) \tag{A.58}$$

$$+ G_{p,t} + AC_{p,t}^{D}$$

To close the model, adjustment costs on deposits are entirely home biased $AC_{i,t}^{D} = \mathcal{G}\left(AC_{i,t}^{D}\left(i\right)^{(\epsilon_P-1)/\epsilon_P}\right)^{\epsilon_P/(\epsilon_P-1)}$, the associated demand function writes, $AC_{i,t}^{D}\left(i\right) = \left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P} AC_{i,t}^{D}$.

1.9.2 Loan Market

The equilibrium on loan market is defined by the aggregate demand function from loans packers in Equation A.30:

$$\mathcal{G}\left(L_{i,t+1}^{s}\left(b\right)\right) = \Delta_{i,t}^{L} L_{i,t+1}^{d}$$

where $\Delta_{i,t}^{L}=\mathcal{G}\left(\frac{r_{i,t}^{L}(b)}{r_{i,t}^{L}}\right)^{-\epsilon_L}$ is the interest rate dispersion term and $L_{i,t+1}^{d}$ is the aggregate demand from home and foreign entrepreneurs, and is defined by:

$$L_{i,t+1}^{d}=\mathcal{G}\left(L_{h,i,t+1}\left(e\right)\right)+\mathcal{G}\left(L_{f,i,t+1}\left(e\right)\right)$$

Recalling that entrepreneurs e borrow to domestic and foreign banks with varieties b produced by wholesale branches, the equilibrium finally writes:

$$\begin{cases} L_{c,t+1}^{s}=\left(\left(1-\alpha_c^L\right)\left[\frac{1+r_{c,t}^L}{1+p_{c,t}^L}\right]^{-\nu}L_{c,t+1}+\frac{n}{n-1}\alpha_p^L\left[\frac{1+r_{c,t}^L}{1+p_{p,t}^L}\right]^{-\nu}L_{p,t}\right)\Delta_{c,t}^L \\ L_{p,t+1}^{s}=\left(\left(1-\alpha_p^L\right)\left[\frac{1+r_{p,t}^L}{1+p_{p,t}^L}\right]^{-\nu}L_{p,t+1}+\frac{n-1}{n}\alpha_c^L\left[\frac{1+r_{p,t}^L}{1+p_{c,t}^L}\right]^{-\nu}L_{c,t}\right)\Delta_{p,t}^L \end{cases} \tag{A.59}$$

Aggregate loan rate index evolves according to:

$$\left(r_{i,t}^{L}\right)^{1-\epsilon_L}=\theta_i^L\left(r_{i,t-1}^{L}\right)^{1-\epsilon_L}+\left(1-\theta_i^L\right)\left(r_{i,t}^{L}\right)^{1-\epsilon_L} \tag{A.60}$$

1.9.3 Interbank Market

On the perfectly competitive interbank market, it clears when the following condition holds for each area:

$$\begin{cases} IB_{c,t+1}^{s}=\frac{\lambda}{1-\lambda}\left(\left(1-\alpha_c^{IB}\right)\left[\frac{1+r_{c,t}^{IB}}{1+p_{c,t}^{L}}\right]^{-\xi}IB_{c,t+1}^{d}+\frac{n}{n-1}\alpha_p^{IB}\left[\frac{1+r_{c,t}^{IB}}{1+p_{p,t}^{IB}}\right]^{-\xi}IB_{p,t}^{d}\right) \\ IB_{p,t+1}^{s}=\frac{\lambda}{1-\lambda}\left(\left(1-\alpha_p^{IB}\right)\left[\frac{1+r_{p,t}^{IB}}{1+p_{p,t}^{IB}}\right]^{-\xi}IB_{p,t+1}^{d}+\frac{n-1}{n}\alpha_c^{IB}\left[\frac{1+r_{p,t}^{L}}{1+p_{c,t}^{L}}\right]^{-\xi}IB_{c,t}^{d}\right) \end{cases} \tag{A.61}$$

1.9.4 Deposit Market

The equilibrium on deposit market is defined by the aggregate demand for deposits services of households and the aggregate supply from deposit packers. Aggregating the demand function from deposit packers in Equation A.29 leads to the equilibrium on this market:

$$\mathcal{G}\left(D_{i,t+1}\left(b\right)\right)=\Delta_{i,t}^{D}\mathcal{G}\left(D_{i,t+1}^{d}\left(j\right)\right) \tag{A.62}$$

where $\Delta_{i,t}^{D}=\mathcal{G}\left(\frac{r_{i,t}^{D}(b)}{r_{i,t}^{D}}\right)^{-\epsilon_D}$ is the interest rate dispersion term, while the aggregate deposit rate index evolves according to:

$$\left(r_{i,t}^{D}\right)^{1-\epsilon_D}=\theta_i^D\left(r_{i,t-1}^{D}\right)^{1-\epsilon_D}+\left(1-\theta_i^D\right)\left(r_{i,t}^{D}\right)^{1-\epsilon_D} \tag{A.63}$$

2 Definitions for Higher-Order Approximations

To compte an accurate value of welfare, we compute a second order approximation around the steady state. To that purpose, we need to specify to dynare the non-linear equations (more than 170) of our model to let dynare handle all the non-linearities and approximate the policy function up to a second order. We need to re-write all the new Keynesian Phillips curves and the welfare criterion by removing the infinite sum that cannot be handled directly by any computer.

2.1 The welfare index

In each country, we compute the fraction of consumption stream from alternative monetary policy regime to be added (or subtracted) to achieve the benchmark reference. The welfare of aggregate households in country i writes:

$$\mathcal{W}_{i,t} = \mathbb{E}_t \sum\nolimits_{\tau=0}^{\infty} \beta^{\tau} \mathcal{U}_i \left(C_{i,t+\tau}, H_{i,t+\tau} \right), \ i = c, p \tag{A.64}$$

where the utility function is defined by:

$$\mathcal{U}\left(C_{i,t}, H_{i,t}\right) = e^{\varepsilon^U_{i,t}} \left(\frac{\left(C_{i,t} - h_i^C C_{i,t-1}\right)^{1-\sigma^C}}{1-\sigma^C} - \chi_i \frac{H_{i,t}^{1+\sigma^L}}{1+\sigma^L} \right) - \lambda^R \left(r_t - \bar{r}\right)^2 \tag{A.65}$$

Following Darracq-Pariès et al. (2011) and Woodford (2003), we account for the zero lower bound by adding to the utility function a term $\lambda^R \left(r_t - \bar{r}\right)^2$ that makes the probability of hitting the zero lower bound shrink. Assuming that the Eurosytem authorities are concerned by the mean welfare of the two countries, we defined the welfare objective $\mathcal{W}_{u,t}$ of the monetary union by the arithmetical average according to the size of each area composing the union:

$$\mathcal{W}_{u,t} = n\mathcal{W}_{c,t} + (1-n)\,\mathcal{W}_{p,t} \tag{A.66}$$

We consider $\mathcal{W}^b_{i,t}$ and $\mathcal{W}^a_{i,t}$ the welfare indexes generated by policy regimes b and a. Parameter ψ denotes the cost of leaving regime a for the regime b in terms of unconditional consumption for households populating the economy. The no-arbitrage condition between implementing the regimes a and b is determined by the following equality:

$$\mathcal{W}^a_{u,t}\left(C^a_{u,t+\tau}, H^a_{u,t+\tau}\right) = \mathcal{W}^b_{u,t}\left(\left(1-\psi\right) C^b_{u,t+\tau}, H^b_{u,t+\tau}\right), \ \tau \geq 0 \tag{A.67}$$

Where ψ $\times 100$ measures the welfare cost in percentage points of permanent consumption of leaving regime a for the regime b.

Developing Equation A.67 leads to:

$$\mathcal{W}_{u,t}^{a} = (1-\psi)^{1-\sigma^C}\,\mathcal{W}_{u,t}^{b} + \left((1-\psi)^{1-\sigma^C} - 1\right)\mathcal{H}_{u,t}^{b}$$

Where $\mathcal{H}_{u,t}^{b}$ writes:

$$\mathcal{H}_{u,t}^{b} = \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} \left\{ e^{\varepsilon_{u,t+\tau}^{U}} \chi_u \frac{\left(H_{u,t+\tau}^{b}\right)^{1+\sigma^L}}{1+\sigma^L} + \lambda^R \left(r_{t+\tau}^{b} - \bar{r}\right)^2 \right\}$$

Put in a recursive fashion, for each country, $\mathcal{H}_{i,t}^{b}$, writes:

$$\mathcal{H}_{u,t}^{b} = \chi_u e^{\varepsilon_{u,t}^{U}} \frac{\left(H_{u,t}^{b}\right)^{1+\sigma^L}}{1+\sigma^L} + \lambda^R \left(r_t^b - \bar{r}\right)^2 + \beta \mathbb{E}_t \mathcal{H}_{u,t+1}^{b} \tag{A.68}$$

To sum up ours calculations, we add in the model 4 equations. First, the equations that define the welfare index of home and foreign country are:

$$\begin{cases} \mathcal{W}_{c,t} = \mathcal{U}_c\left(C_{c,t}, H_{c,t}\right) + \beta \mathbb{E}_t \mathcal{W}_{c,t+1} \\ \mathcal{W}_{p,t} = \mathcal{U}_p\left(C_{p,t}, H_{p,t}\right) + \beta \mathbb{E}_t \mathcal{W}_{p,t+1} \end{cases} \tag{A.69}$$

and equations that are required to convert welfare in terms of unconditional consumption are:

$$\begin{cases} \mathcal{H}_{c,t} = \chi_c e^{\varepsilon_{c,t}^{U}} \frac{H_{c,t}^{1+\sigma^L}}{1+\sigma^L} + \lambda^R \left(r_t - \bar{r}\right)^2 + \beta \mathbb{E}_t \mathcal{H}_{c,t+1} \\ \mathcal{H}_{p,t} = \chi_p e^{\varepsilon_{p,t}^{U}} \frac{H_{p,t}^{1+\sigma^L}}{1+\sigma^L} + \lambda^R \left(r_t - \bar{r}\right)^2 + \beta \mathbb{E}_t \mathcal{H}_{p,t+1} \end{cases} \tag{A.70}$$

After solving the model under regime a and b, we obtain the asymptotic mean, denoted $\mathbb{E}\left[.\right]$, of $\mathcal{W}_{c,t}^{a}$, $\mathcal{W}_{p,t}^{a}$, $\mathcal{W}_{c,t}^{b}$, $\mathcal{W}_{p,t}^{b}$ $\mathcal{H}_{c,t}^{b}$, $\mathcal{H}_{p,t}^{b}$. We measure the welfare cost by finding the value of ψ that solves:

$$\begin{aligned} n\mathbb{E}\left[\mathcal{W}_{c,t}^{a}\right] + (1-n)\,\mathbb{E}\left[\mathcal{W}_{p,t}^{a}\right] &= n\left((1-\psi)^{1-\sigma^C}\left(\mathbb{E}\left[\mathcal{W}_{h,t}^{b}\right] + \mathbb{E}\left[\mathcal{H}_{h,t}^{b}\right]\right) - \mathbb{E}\left[\mathcal{H}_{h,t}^{b}\right]\right) \\ &\quad + (1-n)\left((1-\psi)^{1-\sigma^C}\left(\mathbb{E}\left[\mathcal{W}_{p,t}^{b}\right] + \mathbb{E}\left[\mathcal{H}_{p,t}^{b}\right]\right) - \mathbb{E}\left[\mathcal{H}_{p,t}^{b}\right]\right) \end{aligned} \tag{A.71}$$

We cannot find an analytical solution of the problem, we use matlab solver to get the numerical solution.

On the other hand, the consumption loss ψ_i experienced by households living in country i is determined by:

$$E\left[\mathcal{W}_{i,t}^{a}\right] = (1-\psi_i)^{1-\sigma^C}\left(\mathbb{E}\left[\mathcal{W}_{i,t}^{b}\right] + \mathbb{E}\left[\mathcal{H}_{i,t}^{b}\right]\right) - \mathbb{E}\left[\mathcal{H}_{i,t}^{b}\right] \tag{A.72}$$

2.2 New Keynesian Phillips curves in a recursive fashion

2.2.1 Sticky Price

Denoting by $p^*_{i,t}$ the relative price defined by, $p^*_{i,t} = P^*_{i,t}/P^C_{i,t}$, then we divide by $\left(P^C_{i,t}\right)^{1-\epsilon_P}$, the aggregate price:

$$1 = \left(1-\theta^P_i\right)\left(p^*_{i,t}\right)^{1-\epsilon_P} + \theta^P_i \left(\frac{\pi^{\xi^P_i}_{i,t-1}}{\pi^C_{i,t}}\right)^{1-\epsilon_P} \tag{A.73}$$

the dispersion term, $\Delta^P_{i,t} = \mathcal{G}\left(\frac{P_{i,t}(i)}{P_{i,t}}\right)^{-\epsilon_P}$, written in a recursive fashion is determined by:

$$\Delta^P_{i,t} = \left(1-\theta^P_i\right)\left(p^*_{i,t}\right)^{-\epsilon_P} + \theta^P_i \left(\frac{\pi^C_{i,t}}{\pi^{\xi^P_i}_{i,t-1}}\right)^{\epsilon_P} \Delta^P_{i,t-1} \tag{A.74}$$

Denoting the real marginal cost $mc_{i,t} = MC_{i,t}/P^C_{i,t}$ and $p^*_{i,t} = P^*_{i,t}/P^C_{i,t}$, we rewrite in real terms the first order condition of intermediate firms under *ex ante* symmetry hypothesis:

$$\mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left[\left(\prod_{j=1}^{\tau} \frac{\pi^{\xi^P_i}_{i,t-1+j}}{\pi^C_{i,t+j}}\right)^{1-\epsilon_P} p^*_{i,t} - \frac{\epsilon_P}{\epsilon_P - 1} e^{\gamma^P_i \varepsilon^P_{i,t+\tau}} \left(\prod_{j=1}^{\tau} \frac{\pi^{\xi^P_i}_{i,t-1+j}}{\pi^C_{i,t+j}}\right)^{-\epsilon_P} mc_{i,t+\tau}\right] Y_{i,t+\tau} = 0$$

to simplify the equation, we split the sum:

$$\begin{cases} \mathcal{S}^1_{i,t} = \mathbb{E}_t \sum_{\tau=0}^{\infty} \left(\beta\theta^P_i\right)^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left(\prod_{j=1}^{\tau} \frac{\pi^{\xi^P_i}_{i,t-1+j}}{\pi^C_{i,t+j}}\right)^{1-\epsilon_P} p^*_{i,t} Y_{i,t+\tau} \\ \mathcal{S}^2_{i,t} = \mathbb{E}_t \sum_{\tau=0}^{\infty} \left(\beta\theta^P_i\right)^\tau \frac{\lambda^c_{i,t+\tau}}{\lambda^c_{i,t}} \left(\prod_{j=1}^{\tau} \frac{\pi^{\xi^P_i}_{i,t-1+j}}{\pi^C_{i,t+j}}\right)^{-\epsilon_P} \frac{\epsilon_P}{(\epsilon_P-1)} e^{\gamma^P_i \varepsilon^P_{i,t+\tau}} mc_{i,t+\tau} Y_{i,t+\tau} \\ \mathcal{S}^1_{i,t} = \mathcal{S}^2_{i,t} \end{cases}$$

Thus we can write the sums $\mathcal{S}^1_{i,t}$ and $\mathcal{S}^2_{i,t}$ in a recursive fashion. Finally, the new Keynesian Phillips curve writes:

$$\begin{cases} \mathcal{S}^1_{i,t} = \left(p^*_{i,t}\right)^{-\epsilon_P} Y_{i,t} + \beta\theta^P_i \mathbb{E}_t \frac{\lambda^c_{i,t+1}}{\lambda^c_{i,t}} \left(\frac{\pi^{\xi^P_i}_{i,t}}{\pi^C_{i,t+1}}\right)^{1-\epsilon_P} \left(\frac{p^*_{i,t+1}}{p^*_{i,t}}\right)^{\epsilon_P} \mathcal{S}^1_{i,t+1} \\ \mathcal{S}^2_{i,t} = \left(p^*_{i,t}\right)^{-1-\epsilon_P} Y_{i,t} mc_{i,t} \frac{\epsilon_P}{(\epsilon_P-1)} e^{\gamma^P_i \varepsilon^P_{i,t}} + \beta\theta^P_i \mathbb{E}_t \frac{\lambda^c_{i,t+1}}{\lambda^c_{i,t}} \left(\frac{\pi^{\xi^P_i}_{i,t}}{\pi^C_{i,t+1}}\right)^{-\epsilon_P} \left(\frac{p^*_{i,t+1}}{p^*_{i,t}}\right)^{1+\epsilon_P} \mathcal{S}^2_{i,t+1} \\ \mathcal{S}^1_{i,t} = \mathcal{S}^2_{i,t} \end{cases} \tag{A.75}$$

To summarize, we use Equation A.73, Equation A.74 and Equation A.75 to perform higher-order approximations of the sticky price model.

2.3 Sticky Wage

Denoting by $w_{i,t}^{*}$ the real optimal wage defined by, $w_{i,t}^{*}=W_{i,t}^{*}/P_{i,t}^{C}$ and $w_{i,t}=W_{i,t}/P_{i,t}^{C}$ the real wage, then we divide by $\left(P_{i,t}^{C}\right)^{1-\epsilon_P}$, the aggregate real wage writes:

$$w_{i,t}=\left(1-\theta_i^W\right)\left(w_{i,t}^{*}\right)^{1-\epsilon_W}+\theta_i^W\left(w_{i,t-1}\frac{\left(\pi_{i,t-1}^{C}\right)^{\xi_i^W}}{\pi_{i,t}^{C}}\right)^{1-\epsilon_W} \tag{A.76}$$

the dispersion term, $\Delta_{i,t}^{W}=\mathcal{G}\left(\frac{W_{i,t}(i)}{W_{i,t}}\right)^{-\epsilon_W}$, written in a recursive fashion is determined by:

$$\Delta_{i,t}^{W}=\left(1-\theta_i^W\right)\left(\frac{w_{i,t}^{*}}{w_{i,t}}\right)^{-\epsilon_W}+\theta_i^W\left(\frac{w_{i,t-1}}{w_{i,t}}\frac{\pi_{i,t}^{C}}{\left(\pi_{i,t-1}^{C}\right)^{\xi_i^W}}\right)^{\epsilon_W}\Delta_{i,t-1}^{W} \tag{A.77}$$

Under *ex ante* symmetry hypothesis, the first order condition of the bank allowed to reset its wage reads as follows:

$$w_{i,t}^{*}=\frac{\mathbb{E}_t\sum_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\frac{\varepsilon_W}{\varepsilon_W-1}e^{\gamma_i^W\varepsilon_{i,t+\tau}^{W}}w_{i,t+\tau}^{h}H_{i,t+\tau}^{d}}{\mathbb{E}_t\sum_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\prod_{k=1}^{\tau}\frac{\left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^W}}{\pi_{i,t+k}^{C}}H_{i,t+\tau}^{d}}$$

where $w_{i,t+\tau}^{h}=W_{i,t+\tau}^{h}/P_{i,t+\tau}^{C}$ is the households real marginal utility of supplying labour. To simplify the equation, we split the sum:

$$\begin{cases}\mathcal{V}_{i,t}^{1}=\mathbb{E}_t\sum_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\prod_{k=1}^{\tau}\frac{\left(\pi_{i,t+k-1}^{C}\right)^{\xi_i^w}}{\pi_{i,t+k}^{C}}w_{i,t}^{*}H_{i,t+\tau}^{d},\\ \mathcal{V}_{i,t}^{2}=\mathbb{E}_t\sum_{\tau=0}^{\infty}\left(\theta_i^W\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\frac{\varepsilon_W}{\varepsilon_W-1}e^{\gamma_i^W\varepsilon_{i,t+\tau}^{W}}w_{i,t+\tau}^{h}H_{i,t+\tau}^{d},\\ \mathcal{V}_{i,t}^{1}=\mathcal{V}_{i,t}^{2}.\end{cases}$$

Thus we can write the sums $\mathcal{V}_{i,t}^{1}$ and $\mathcal{V}_{i,t}^{2}$ in a recursive fashion. Finally, the new Keynesian Phillips curve writes:

$$\begin{cases}\mathcal{V}_{i,t}^{1}=\left(\frac{w_{i,t}}{w_{i,t}^{*}}\right)^{\epsilon_W}H_{i,t}^{d}w_{i,t}^{*}+\beta\theta_i^W\mathbb{E}_t\frac{\lambda_{i,t+1}^{c}}{\lambda_{i,t}^{c}}\left(\frac{w_{i,t}^{*}\left(\pi_{i,t}^{C}\right)^{\xi_i^W}}{w_{i,t+1}^{*}\pi_{i,t+1}^{C}}\right)^{1-\epsilon_W}\mathcal{V}_{i,t+1}^{1},\\ \mathcal{V}_{i,t}^{2}=\frac{\epsilon_W}{(\epsilon_W-1)}e^{\gamma_i^W\varepsilon_{i,t}^{W}}\left(\frac{w_{i,t}^{*}}{w_{i,t}}\right)^{-\epsilon_W}H_{i,t}^{d}w_{i,t}^{h}+\beta\theta_i^W\mathbb{E}_t\frac{\lambda_{i,t+1}^{c}}{\lambda_{i,t}^{c}}\left(\frac{w_{i,t}^{*}\left(\pi_{i,t}^{C}\right)^{\xi_i^W}}{w_{i,t+1}^{*}\pi_{i,t+1}^{C}}\right)^{-\epsilon_W}\mathcal{V}_{i,t+1}^{2},\\ \mathcal{V}_{i,t}^{1}=\mathcal{V}_{i,t}^{2}.\end{cases} \tag{A.78}$$

To summarize, we use Equation A.76, Equation A.77 and Equation A.78 to perform higher-order approximations of the sticky wage model.

2.3.1 Sticky Credit Rate

We divide by $\left(r_{i,t}^{L}\right)^{1-\epsilon_L}$ the aggregate rate, we get:

$$1=\theta_i^D\left(\frac{r_{i,t-1}^L}{r_{i,t}^L}\right)^{1-\epsilon_L}+\left(1-\theta_i^L\right)\left(\frac{r_{i,t}^{L*}}{r_{i,t}^L}\right)^{1-\epsilon_L}, \tag{A.79}$$

The dispersion term between all the varieties of loans b in the economy, $\Delta_{i,t}^L=\mathcal{G}\left(r_{i,t}^L\left(b\right)/r_{i,t}^L\right)^{-\epsilon_L}$, can be rewritten as a law motion such as:

$$\Delta_{i,t}^L=\left(1-\theta_i^L\right)\left(\frac{r_{i,t}^{L*}}{r_{i,t}^L}\right)^{-\epsilon_L}+\theta_i^L\left(\frac{r_{i,t-1}^L}{r_{i,t}^L}\right)^{-\epsilon_L}\Delta_{i,t-1}^L. \tag{A.80}$$

Under *ex ante* symmetry hypothesis, the first order condition of the bank allowed to reset its credit rates reads as follows:

$$\sum\nolimits_{\tau=0}^{\infty}\left(\theta_i^L\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c}\left[R_{i,t}^{L*}-\frac{\epsilon_L}{\epsilon_L-1}e^{\gamma_i^L\varepsilon_{i,t+\tau}^L}MC_{i,t+\tau}^L\right]\left(\frac{r_{i,t}^{L*}}{r_{i,t+\tau}^L}\right)^{-\epsilon_L}L_{i,t+1+\tau}^d=0.$$

To simplify the equation, we split the sum in two terms $\mathcal{B}_{i,t}^1$ and $\mathcal{B}_{i,t}^2$:

$$\begin{cases}\mathcal{B}_{i,t}^1=\mathbb{E}_t\sum\nolimits_{\tau=0}^{\infty}\left(\beta\theta_i^L\right)^{\tau}\frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c}r_{i,t}^{L*}\left(\frac{r_{i,t}^{L*}}{r_{i,t+\tau}^L}\right)^{-\epsilon_L}L_{i,t+1+\tau}^d\\ \mathcal{B}_{i,t}^2=\mathbb{E}_t\sum\nolimits_{\tau=0}^{\infty}\left(\beta\theta_i^L\right)^{\tau}\frac{\lambda_{i,t+\tau}^c}{\lambda_{i,t}^c}\frac{\epsilon_L}{\epsilon_L-1}e^{\gamma_i^L\varepsilon_{i,t+\tau}^L}MC_{i,t+\tau}^L\left(\frac{r_{i,t}^{L*}}{r_{i,t+\tau}^L}\right)^{-\epsilon_L}L_{i,t+1+\tau}^d\\ \mathcal{B}_{i,t}^1=\mathcal{B}_{i,t}^2\end{cases}$$

Thus we can write the sums $\mathcal{B}_{i,t}^1$ and $\mathcal{B}_{i,t}^2$ in a recursive fashion. Finally, the new Keynesian Phillips curve for credit rates writes:

$$\begin{cases}\mathcal{B}_{i,t}^1=L_{i,t+1}^d\left(\frac{r_{i,t}^L}{r_{i,t}^{L*}}\right)^{\epsilon_L}r_{i,t}^{L*}+\beta\theta_i^L\mathbb{E}_t\frac{\lambda_{i,t+1}^c}{\lambda_{i,t}^c}\left(\frac{r_{i,t}^{L*}}{r_{i,t+1}^{L*}}\right)^{1-\epsilon_L}\mathcal{B}_{i,t+1}^1\\ \mathcal{B}_{i,t}^2=\frac{\epsilon_L}{\epsilon_L-1}e^{\gamma_i^L\varepsilon_{i,t}^L}MC_{i,t}^LL_{i,t+1}^d\left(\frac{r_{i,t}^L}{r_{i,t}^{L*}}\right)^{\epsilon_L}+\beta\theta_i^L\mathbb{E}_t\frac{\lambda_{i,t+1}^c}{\lambda_{i,t}^c}\left(\frac{r_{i,t}^{L*}}{r_{i,t+1}^{L*}}\right)^{-\epsilon_L}\mathcal{B}_{i,t+1}^2\\ \mathcal{B}_{i,t}^1=\mathcal{B}_{i,t}^2\end{cases} \tag{A.81}$$

To summarize, we use Equation A.79, Equation A.80 and Equation A.81 to perform higher-order approximations of the sticky wage model.

2.3.2 Sticky Deposit Rate

We divide by $\left(r_{i,t}^{D}\right)^{1-\epsilon_D}$, the aggregate rate writes:

$$1=\theta_i^D\left(\frac{r_{i,t-1}^{D}}{r_{i,t}^{D}}\right)^{1-\epsilon_D}+\left(1-\theta_i^D\right)\left(\frac{r_{i,t}^{D*}}{r_{i,t}^{D}}\right)^{1-\epsilon_D} \tag{A.82}$$

the dispersion term, $\Delta_{i,t}^{D}=\mathcal{G}\left(\frac{r_{i,t}^{D}(b)}{r_{i,t}^{D}}\right)^{-\epsilon_D}$ is defined by:

$$\Delta_{i,t}^{D}=\left(1-\theta_i^D\right)\left(\frac{r_{i,t}^{D*}}{r_{i,t}^{D}}\right)^{-\epsilon_D}+\theta_i^D\left(\frac{r_{i,t-1}^{D}}{r_{i,t}^{D}}\right)^{-\epsilon_D}\Delta_{i,t-1}^{D} \tag{A.83}$$

Under *ex ante* symmetry hypothesis, the first order condition of the bank allowed to reset its deposit rates reads as follows:

$$\sum\nolimits_{\tau=0}^{\infty}\left(\theta_i^D\beta\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}\left[r_{i,t}^{D*}-\frac{\epsilon_D}{\epsilon_D-1}e^{\gamma_i^D\varepsilon_{i,t+\tau}^{D}}MC_{i,t+\tau}^{L}\right]\left(\frac{r_{i,t}^{D*}}{r_{i,t+\tau}^{D}}\right)^{-\epsilon_D}L_{i,t+1+\tau}^{d}=0$$

to simplify the equation, we split the sum:

$$\left\{\begin{array}{c}\mathcal{D}_{i,t}^{1}=\mathbb{E}_t\sum\nolimits_{\tau=0}^{\infty}\left(\beta\theta_i^D\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}r_{i,t}^{D*}\left(\frac{r_{i,t}^{D*}}{r_{i,t+\tau}^{L}}\right)^{-\epsilon_D}D_{i,t+1+\tau}^{d},\\ \mathcal{D}_{i,t}^{2}=\mathbb{E}_t\sum\nolimits_{\tau=0}^{\infty}\left(\beta\theta_i^D\right)^{\tau}\frac{\lambda_{i,t+\tau}^{c}}{\lambda_{i,t}^{c}}e^{\gamma_i^D\varepsilon_{i,t+\tau}^{D}}\frac{\epsilon_D}{\epsilon_D-1}MC_{i,t+\tau}^{D}\left(\frac{r_{i,t}^{D*}}{r_{i,t+\tau}^{D}}\right)^{-\epsilon_D}D_{i,t+1+\tau}^{d},\\ \mathcal{D}_{i,t}^{1}=\mathcal{D}_{i,t}^{2}.\end{array}\right.$$

Thus we can write the sums $\mathcal{D}_{i,t}^{1}$ and $\mathcal{D}_{i,t}^{2}$ in a recursive fashion. Finally, the new Keynesian Phillips curve for deposit rates writes:

$$\left\{\begin{array}{c}\mathcal{D}_{i,t}^{1}=D_{i,t+1}^{d}\left(\frac{r_{i,t}^{D}}{r_{i,t}^{D*}}\right)^{\epsilon_D}R_{i,t}^{D*}+\beta\theta_i^D\mathbb{E}_t\frac{\lambda_{i,t+1}^{c}}{\lambda_{i,t}^{c}}\left(\frac{r_{i,t}^{D*}}{r_{i,t+1}^{D*}}\right)^{1-\epsilon_D}\mathcal{D}_{i,t+1}^{1},\\ \mathcal{D}_{i,t}^{2}=e^{\gamma_i^D\varepsilon_{i,t}^{D}}\frac{\epsilon_D}{\epsilon_D-1}MC_{i,t+\tau}^{D}D_{i,t+1}^{d}\left(\frac{r_{i,t}^{D}}{r_{i,t}^{D*}}\right)^{\epsilon_D}+\beta\theta_i^D\mathbb{E}_t\frac{\lambda_{i,t+1}^{c}}{\lambda_{i,t}^{c}}\left(\frac{r_{i,t}^{D*}}{r_{i,t+1}^{D*}}\right)^{-\epsilon_D}\mathcal{D}_{i,t+1}^{2},\\ \mathcal{D}_{i,t}^{1}=\mathcal{D}_{i,t}^{2}.\end{array}\right. \tag{A.84}$$

Appendix B

The Linear Model

This appendix presents the log-linearized version of the model described in Chapter 2. We rewrite all the equations in real terms as in open economy model prices posses a random walk component.

1 Households

Euler Equation 2.13 taken in logs:

$$\left\{\begin{array}{l} \sigma_h^C\left(E_t\hat{c}_{h,t+1}-\left(1+h_h^C\right)\hat{c}_{h,t}+h_h^C\hat{c}_{h,t-1}\right)=\left(1-h_h^C\right)\left(\hat{r}_t-\mathbb{E}_t\hat{\pi}^C_{h,t+1}+\hat{\varepsilon}^U_{h,t+1}-\hat{\varepsilon}^U_{h,t}-C\chi^B\hat{b}_{h,t}\right)\\ \sigma_f^C\left(E_t\hat{c}_{f,t+1}-\left(1+h_f^C\right)\hat{c}_{f,t}+h_f^C\hat{c}_{f,t-1}\right)=\left(1-h_f^C\right)\left(\hat{r}_t-\mathbb{E}_t\hat{\pi}^C_{f,t+1}+\hat{\varepsilon}^U_{f,t+1}-\hat{\varepsilon}^U_{f,t}+C\chi^B\hat{b}_{h,t}\right)\end{array}\right. . \tag{B.1}$$

The hours supply Equation 2.14 is determined by:

$$\hat{w}^h_{i,t}=\frac{1}{\sigma_i^L}\hat{h}_{i,t}+\frac{\sigma_i^C}{\left(1-h_i^C\right)}\left(\hat{c}_{i,t}-h_i^C\hat{c}_{i,t-1}\right). \tag{B.2}$$

2 Unions

The staggered real wage equation Equation 2.16 combined with aggregate wage index equation Equation 2.31 give rise to the new Keynesian Phillips curve for wages:

$$\begin{aligned}(1+\beta)\,\hat{w}_{i,t}=\;&\xi_i^W\hat{\pi}^C_{i,t-1}+\hat{w}_{i,t-1}-\left(1+\beta\xi_i^W\right)\hat{\pi}^C_{i,t}+\beta\mathbb{E}_t\left(\hat{w}_{i,t+1}+\hat{\pi}^C_{i,t+1}\right)\\ &+\frac{\left(1-\beta\theta_i^W\right)\left(1-\theta_i^W\right)}{\theta_i^W}\left(\hat{w}^h_{i,t}-\hat{w}_{i,t}\right).\end{aligned} \tag{B.3}$$

3 Firms

The production function in Equation 2.17 writes:

$$\hat{y}_{i,t} = \hat{\varepsilon}^A_{i,t} + \alpha \hat{k}^u_{i,t} + (1-\alpha)\,\hat{h}_{i,t}. \tag{B.4}$$

The marginal cost in Equation 2.18 is:

$$\widehat{mc}_{i,t} = \alpha \hat{z}_{i,t} + (1-\alpha)\,\hat{w}_{i,t} - \hat{\varepsilon}^A_{i,t}, \tag{B.5}$$

and inputs are linked by:

$$\hat{w}_{i,t} + \hat{h}_{i,t} = \hat{k}^u_{i,t} + \hat{z}_{i,t}. \tag{B.6}$$

Taking in logs, Equation 2.20 and Equation 2.30 give rise to the new Keynesian Phillips curve for prices:

$$\begin{cases} \left(1+\xi^P_h\right)\hat{\pi}^C_{h,t} = \xi^P_h \hat{\pi}^C_{h,t-1} + \beta \mathbb{E}_t \hat{\pi}^C_{h,t+1} + \frac{\left(1-\beta\theta^P_h\right)\left(1-\theta^P_h\right)}{\theta^P_h}\left(\widehat{mc}_{h,t} + \alpha^C \widehat{ToT}_t\right) \\ \left(1+\xi^P_f\right)\hat{\pi}^C_{f,t} = \xi^P_f \hat{\pi}^C_{f,t-1} + \beta \mathbb{E}_t \hat{\pi}^C_{f,t+1} + \frac{\left(1-\beta\theta^P_f\right)\left(1-\theta^P_f\right)}{\theta^P_f}\left(\widehat{mc}_{f,t} - \alpha^C \widehat{ToT}_t\right) \end{cases}. \tag{B.7}$$

The home final demand in Equation 2.29 is:

$$\begin{aligned} \hat{y}_{h,t} = {} & \frac{\bar{C}}{\bar{Y}}\left(\left(1-\alpha^C\right)\hat{c}_{h,t} + \alpha^C \hat{c}_{f,t}\right) + \frac{\bar{I}}{\bar{Y}}\left(\left(1-\alpha^I\right)\hat{\imath}_{h,t} + \alpha^I \hat{\imath}_{f,t}\right) + \frac{\bar{G}}{\bar{Y}}\varepsilon^G_{h,t} + \bar{Z}\bar{K}\hat{u}_{h,t} \\ & + 2\mu\left(\frac{\bar{C}}{\bar{Y}}\alpha^C\left(1-\alpha^C\right) + \frac{\bar{I}}{\bar{Y}}\alpha^I\left(1-\alpha^I\right)\right)\widehat{ToT}_t, \end{aligned} \tag{B.8}$$

and its foreign counterpart:

$$\begin{aligned} \hat{y}_{f,t} = {} & \frac{\bar{C}}{\bar{Y}}\left(\left(1-\alpha^C\right)\hat{c}_{f,t} + \alpha^C \hat{c}_{h,t}\right) + \frac{\bar{I}}{\bar{Y}}\left(\left(1-\alpha^I\right)\hat{\imath}_{f,t} + \alpha^I \hat{\imath}_{h,t}\right) + \frac{\bar{G}}{\bar{Y}}\varepsilon^G_{f,t} + \bar{Z}\bar{K}\hat{u}_{f,t} \\ & - 2\mu\left(\frac{\bar{C}}{\bar{Y}}\alpha^C\left(1-\alpha^C\right) + \frac{\bar{I}}{\bar{Y}}\alpha^I\left(1-\alpha^I\right)\right)\widehat{ToT}_t. \end{aligned} \tag{B.9}$$

As in Bernanke et al. (1999), we assume that the defaulting share of investment projects is second order (*i.e.* we neglect them in our first order approximation of our equilibrium conditions).

4 Entrepreneurs

The net wealth law of motion in Equation 2.8 writes:

$$\hat{n}_{i,t} = \left(1-\tau^E\right)\frac{\bar{V}}{\bar{N}}\hat{v}_{i,t} - \hat{\varepsilon}^N_{i,t}. \tag{B.10}$$

The one-period-profit equation of entrepreneurs reads:

$$\hat{v}_{i,t} = (1-\kappa)(1-\varkappa_i)\frac{\eta^k}{\eta^k-1}\left(\hat{q}_{i,t-1}+\hat{k}_{i,t-1}-\hat{n}_{i,t-1}\right)+r^k_{i,t}+q_{i,t-1}+k_{i,t-1}, \quad \text{(B.11)}$$

where $\eta^k = \bar{N}/\bar{K}$. The balance sheet of entrepreneurs in Equation 2.1 is:

$$\left(1-\eta^k\right)\left(\hat{l}^d_{i,t}-h^L_i\hat{l}^d_{i,t-1}\right)+\eta^k\hat{n}_{i,t} = \hat{q}_{i,t}+\hat{k}_{i,t}. \quad \text{(B.12)}$$

The external premium (or the firm's spread) in Equation 2.7 is:

$$\hat{s}_{i,t} = \varkappa_i\frac{\eta^k}{\eta^k-1}\left(\hat{q}_{i,t}+\hat{k}_{i,t}-\hat{n}_{i,t}\right)+\varepsilon^Q_{i,t}, \quad \text{(B.13)}$$

where:

$$\hat{s}_{i,t} = \mathbb{E}_t\hat{r}^k_{i,t+1}-\hat{p}^L_{i,t}. \quad \text{(B.14)}$$

The *ex post* threshold in Equation 2.5 reads as follows:

$$\hat{\omega}^c_{i,t}+\hat{r}^k_{i,t}+\hat{q}_{i,t-1}+\hat{k}_{i,t-1} = \hat{p}^L_{i,t-1}+\hat{l}^d_{i,t-1}-h^L_i\hat{l}^d_{i,t-2}. \quad \text{(B.15)}$$

The expected rate of insolvent investment projects is defined by:

$$\hat{\eta}^E_{i,t} = -\kappa\hat{\omega}^c_{i,t}. \quad \text{(B.16)}$$

5 Banks

Credit market equilibrium from equation writes:

$$\begin{cases} \hat{l}^s_{h,t} = \left(1-\alpha^L\right)\hat{l}^d_{h,t}+\alpha^L\hat{l}^d_{f,t}+\alpha^L 2\nu\left(1-\alpha^L\right)\left[\hat{r}^L_{f,t}+\hat{\pi}^C_{f,t}-\hat{r}^L_{h,t}-\hat{\pi}^C_{h,t}\right] \\ \hat{l}^s_{f,t} = \left(1-\alpha^L\right)\hat{l}^d_{f,t}+\alpha^L\hat{l}^d_{h,t}-\alpha^L 2\nu\left(1-\alpha^L\right)\left[\hat{r}^L_{f,t}+\hat{\pi}^C_{f,t}-\hat{r}^L_{h,t}-\hat{\pi}^C_{h,t}\right] \end{cases}. \quad \text{(B.17)}$$

The real marginal cost of one unit of loan in Equation 2.33 is defined by:

$$\widehat{mc}^L_{i,t} = \kappa\frac{\eta^k}{\eta^k-1}\left(\left(1-\alpha^L\right)(1-\varkappa_i)\left(\hat{q}_{i,t}+\hat{k}_{i,t}-\hat{n}_{i,t}\right)+\alpha^L(1-\varkappa_{-i})\left(\hat{q}_{-i,t}+\hat{k}_{-i,t}-\hat{n}_{-i,t}\right)\right)$$

$$+\left(\hat{r}_t-\mathbb{E}_t\hat{\pi}^c_{i,t+1}\right). \quad \text{(B.18)}$$

Mixing Equation 2.26 and Equation 2.32 gives rise to the real credit rate dynamic:

$$\hat{r}_{i,t}^{L}=\frac{1}{1+\beta\left(1+\xi_{i}^{L}\right)}\begin{pmatrix}\left(1+\xi_{i}^{L}\left(1+\beta\right)\right)\hat{r}_{i,t-1}^{L}-\xi_{i}^{L}\hat{r}_{i,t-2}^{L}+\beta\mathbb{E}_{t}\hat{r}_{i,t+1}^{L}\\ +\beta\theta_{i}^{L}\mathbb{E}_{t}\pi_{i,t+2}^{C}-\left(1+\beta\theta_{i}^{L}\right)\mathbb{E}_{t}\pi_{i,t+1}^{C}+\hat{\pi}_{i,t}^{C}\\ +\frac{\left(1-\theta_{i}^{L}\right)\left(1-\theta_{i}^{L}\beta\right)}{\theta_{i}^{L}}\left[\widehat{mc}_{i,t}^{L}-\hat{r}_{i,t}^{L}\right]\end{pmatrix}+\hat{\varepsilon}_{i,t}^{L}, \quad (B.19)$$

and the banking spread is:

$$\hat{s}_{i,t}^{L}=\hat{r}_{i,t}^{L}-\left(\hat{r}_{t}-\mathbb{E}_{t}\hat{\pi}_{i,t+1}^{C}\right). \quad (B.20)$$

6 Capital Supply Decisions

The *ex post* return on capital in Equation 2.23 taken in logs becomes:

$$\begin{cases}\mathbb{E}_{t-1}\hat{r}_{h,t}^{k}=\frac{Z}{R^{k}}\hat{z}_{h,t}+\frac{(1-\delta)}{R^{k}}\hat{q}_{h,t}-\hat{q}_{h,t-1}-\hat{\varepsilon}_{h,t+1}^{U}+\hat{\varepsilon}_{h,t}^{U}+\frac{\bar{C}}{R^{k}}\chi^{B}\hat{b}_{h,t-1}\\ \mathbb{E}_{t-1}\hat{r}_{f,t}^{k}=\frac{Z}{R^{k}}\hat{z}_{f,t}+\frac{(1-\delta)}{R^{k}}\hat{q}_{f,t}-\hat{q}_{f,t-1}-\hat{\varepsilon}_{f,t+1}^{U}+\hat{\varepsilon}_{f,t}^{U}-\frac{\bar{C}}{R^{k}}\chi^{B}\hat{b}_{h,t-1}\end{cases}. \quad (B.21)$$

The law of motion of capital is standard in Equation 2.21 is:

$$\delta\hat{\imath}_{i,t}=\hat{k}_{i,t}-(1-\delta)\,\hat{k}_{i,t-1}, \quad (B.22)$$

and the capital utilized by the intermediate sector is:

$$\hat{k}_{i,t}^{u}=\hat{u}_{i,t}+\hat{k}_{i,t-1}. \quad (B.23)$$

The capital utilization rate is:

$$\frac{\psi_{i}}{1-\psi_{i}}\hat{u}_{i,t}=\hat{z}_{i,t} \quad (B.24)$$

the first order condition of capital producers in real terms in Equation 2.22 writes:

$$\begin{cases}\hat{q}_{h,t}+\left(\alpha^{C}-\alpha^{I}\right)\widehat{ToT}_{t}=\chi_{h}^{I}\left(\hat{\imath}_{h,t}-\hat{\imath}_{h,t-1}\right)-\beta\chi_{h}^{I}\left(\mathbb{E}_{t}\hat{\imath}_{h,t+1}-\hat{\imath}_{h,t}\right),\\ \hat{q}_{f,t}-\left(\alpha^{C}-\alpha^{I}\right)\widehat{ToT}_{t}=\chi_{f}^{I}\left(\hat{\imath}_{f,t}-\hat{\imath}_{f,t-1}\right)-\beta\chi_{f}^{I}\left(\mathbb{E}_{t}\hat{\imath}_{f,t+1}-\hat{\imath}_{f,t}\right).\end{cases} \quad (B.25)$$

7 International Macroeconomics Definitions

Home and foreign consumption price inflation indexes are:

$$\begin{cases}\hat{\pi}_{h,t}^{C}=\hat{\pi}_{h,t}+\alpha^{C}\left(\widehat{ToT}_{t}-\widehat{ToT}_{t-1}\right),\\ \hat{\pi}_{f,t}^{C}=\hat{\pi}_{f,t}-\alpha^{C}\left(\widehat{ToT}_{t}-\widehat{ToT}_{t-1}\right).\end{cases} \quad (B.26)$$

The credit rate index in real terms is:

$$\hat{p}^L_{h,t} = \left(1-\alpha^L\right)\hat{r}^L_{h,t} + \alpha^L \hat{r}^L_{f,t} + \alpha^L \mathbb{E}_t\left(\hat{\pi}^C_{f,t+1} - \hat{\pi}^C_{h,t+1}\right). \tag{B.27}$$

From the home country perspective, the terms of trade is:

$$\widehat{ToT}_t = \hat{\pi}_{f,t} - \hat{\pi}_{h,t} + \widehat{ToT}_{t-1}. \tag{B.28}$$

The home bonds law of motion:

$$\begin{aligned}\hat{b}_{h,t} - \hat{b}_{h,t-1} = &\frac{\bar{C}}{\bar{Y}}\alpha^C\left(c_{f,t} - c_{h,t} + \left(2\mu\left(1-\alpha^I\right)-1\right)\widehat{ToT}_t\right)\\ &+ \frac{\bar{I}}{\bar{Y}}\alpha^I\left(i_{f,t} - i_{h,t} + \left(2\mu\left(1-\alpha^C\right)-1\right)\widehat{ToT}_t\right).\end{aligned} \tag{B.29}$$

The home current account dynamic:

$$\begin{aligned}\widehat{ca}_{h,t} = &\bar{C}\left(\hat{b}_{h,t} - \hat{b}_{h,t-1}\right) + \bar{L}\alpha^L\left(R^L-1\right)\left(\hat{l}^d_{f,t} - \hat{l}^d_{h,t} + \left(1-2\alpha^C\right)\widehat{ToT}_t\right)\\ &+ \bar{L}\alpha^L\left(\bar{R}^L-1\right)\left(2\nu\left(1-\alpha^L\right)-1\right)\left(\hat{r}^L_{f,t} + \hat{\pi}^C_{f,t} - \hat{r}^L_{h,t} - \hat{\pi}^C_{h,t}\right).\end{aligned} \tag{B.30}$$

8 Monetary Policy

And finally, the Taylor rules follows the law of motion in Equation 2.28:

$$\hat{r}_t = \rho^R \hat{r}_{t-1} + \frac{1}{2}\left(1-\rho^R\right)\left[\phi^\pi\left(\hat{\pi}^C_{h,t} + \hat{\pi}^C_{f,t}\right) + \phi^{\Delta y}\left(\hat{y}_{h,t} - \hat{y}_{h,t-1} + \hat{y}_{f,t} - \hat{y}_{f,t-1}\right)\right] + \hat{\eta}^R_t. \tag{B.31}$$

9 Shocks Processes

The shock processes are defined by:

$$\hat{\varepsilon}^A_{i,t} = \rho^A_i \hat{\varepsilon}^A_{i,t-1} + \hat{\eta}^A_{i,t}, \tag{B.32}$$

$$\hat{\varepsilon}^G_{i,t} = \rho^G_i \hat{\varepsilon}^G_{i,t-1} + \hat{\eta}^G_{i,t}, \tag{B.33}$$

$$\hat{\varepsilon}^U_{i,t} = \rho^U_i \hat{\varepsilon}^U_{i,t-1} + \hat{\eta}^U_{i,t}, \tag{B.34}$$

$$\hat{\varepsilon}^Q_{i,t} = \rho^Q_i \hat{\varepsilon}^Q_{i,t-1} + \hat{\eta}^Q_{i,t}, \tag{B.35}$$

$$\hat{\varepsilon}^N_{i,t} = \rho^N_i \hat{\varepsilon}^N_{i,t-1} + \hat{\eta}^N_{i,t}, \tag{B.36}$$

$$\hat{\varepsilon}^L_{i,t} = \rho^L_i \hat{\varepsilon}^L_{i,t-1} + \hat{\eta}^L_{i,t}. \tag{B.37}$$

Appendix C

Additional Quantitative Results

This appendix presents some additional results that are not necessary for the analysis of macroprudential policy and cross-border lending. We develop a model with quantitative properties similar to Smets & Wouters (2003) in a two-country perspective augmented with an international banking system that considers the short-run divergences in the business cycles of the Eurozone.

This appendix is organized as follows: Section 1 presents the prediction performances of the Chapter 4 estimated model. Section 2 presents the driving forces of the business cycles since the Eurosystem creation. Section 3 evaluates the robustness of our quantitative exploration to the zero lower bound. Section 4 examines the historical decomposition of business and credit cycles.

1 Empirical Performances

While obtaining the highest possible data fit was not the primary objective of building our model, it may be useful to take a close look at the forecasting performance of the model. Figure C.1 presents a simple tool to assess the empirical performance of a DSGE model, that consists in casting its one-side Kalman filter predictions of the observable variables against their realizations. The Kalman filter generates projections or forecasts of the state of the linear approximate solution of the DSGE model given an information set of observed macro time series (see for instance Guerrón-Quintana & Nason (2012) for more informations). Thus, we can compare the prediction performances of output, consumption, inflation, investment, loan supply, credit rates, interbank supply, real wages and ECB refinancing rate.

Overall, our model does a good job at tracking the main variables of the Euro Area with some noticeable exceptions:

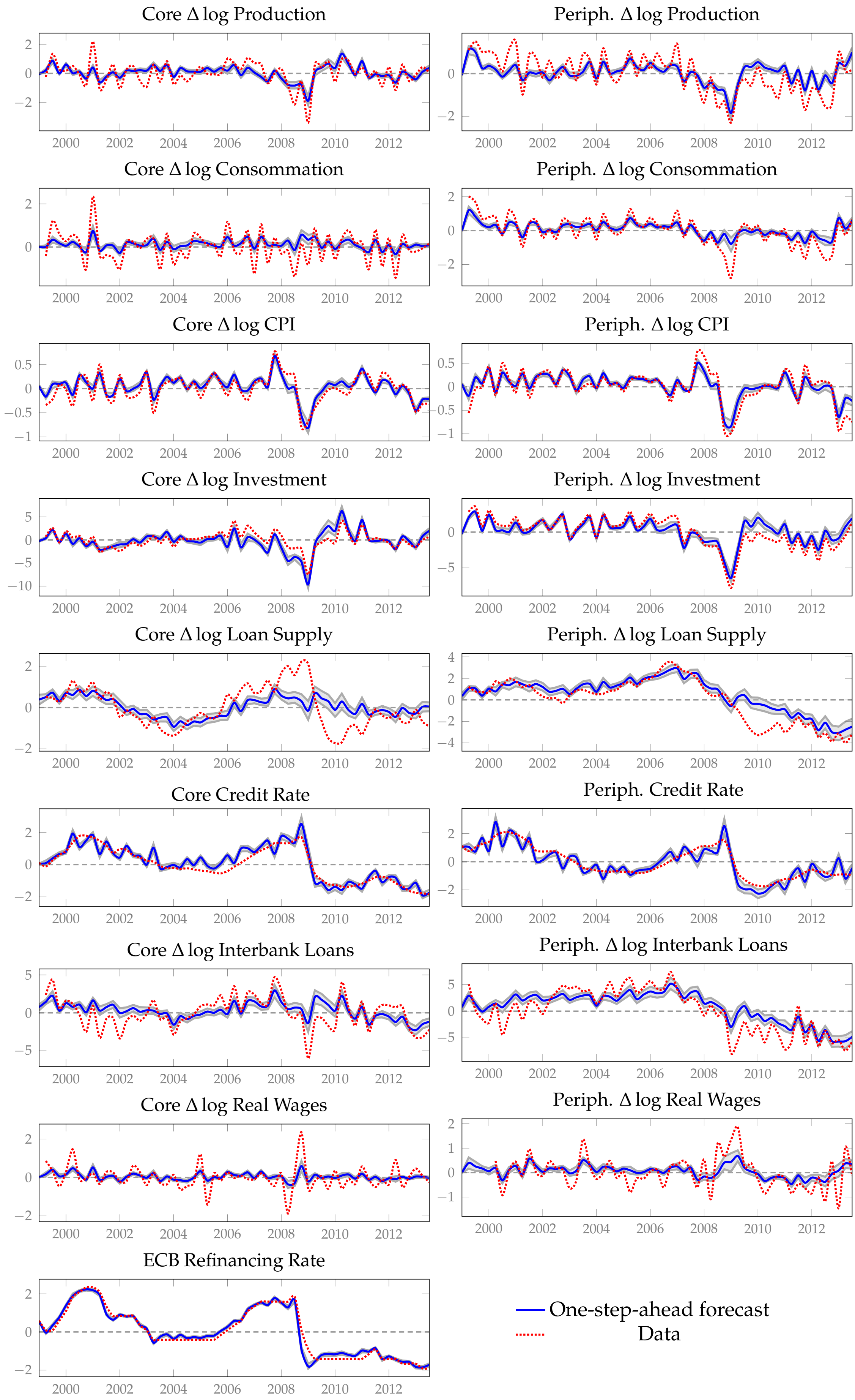


FIGURE C.1: Data and one-step-ahead forecasts generated from Chapter 4 model.

First, the model does not capture the volatility in real wage growth. This issue may be solved by replacing the labour supply equation (*i.e.* the households marginal utility of labour) and the sticky wage model with a better micro-founded labor market friction such as from search-matching models *à la* Christiano et al. (2011).

Second, the model clearly fails at explaining the pre-crisis credit boom for firms in core countries as well as the after-crisis sharp drop in the credit supply from the core banking system. To enhance the forecasting performances of the credit supply in the core area, a more sophisticated bank balance sheet that incorporates housing loans and sovereign bonds could help in catching up these aggregate fluctuations.

In addition, the model performs well at predicting core countries consumption fluctuations but not its volatility size. This failure on consumption has a clear side-effect on the output growth prediction. This problem regarding consumption forecasting is probably related to the real wage growth prediction.

Altogether, the overall in-sample fit of our model seems to be acceptable if one takes into account a highly restrictive nature of the DSGE framework.

2 Driving Forces of Output

As Smets & Wouters (2007), we can study the driving force of output in the Euro Area since its creation in 1999. In Figure C.2, we plot the forecast variance error decomposition of output in core and peripheral areas. All the shocks are gathered according to their type: Supply ($\eta_{i,t}^{A}$); Demand ($\eta_{i,t}^{G}$ and $\eta_{i,t}^{U}$); Financial ($\eta_{i,t}^{Q}$, $\eta_{i,t}^{N}$, $\eta_{i,t}^{L}$ and $\eta_{i,t}^{B}$ and the common shocks); Wage mark-up ($\eta_{i,t}^{W}$) and Monetary policy (η_{t}^{R}).

First, two areas are pretty similar in the forces that drive output fluctuations in the sample period either in the short and in the long run. Supply shocks accounts for about 20% to 35% of business cycles variations. This result is comparable to the Smets & Wouters (2007)'s findings for the US economy. On the other hand, demand shocks only account for 10% of output variations, they are replaced by financial shocks, which appear to be the main drivers of the Euro Area business cycles. This result is not surprising, as banking shocks had a very important role in fuelling the propriety boom followed by a bust cycle, justifying the need for macroprudential measures. In the short run (*i.e.* within a year), real GDP is primarily driven by supply shocks which affects the production function and prices in the Eurozone. In the long run (more than 40 quarters), supply shocks are slightly replaced by financial shocks. In comparison, wage mark-up shocks remain pretty constant over the forecasting horizon.

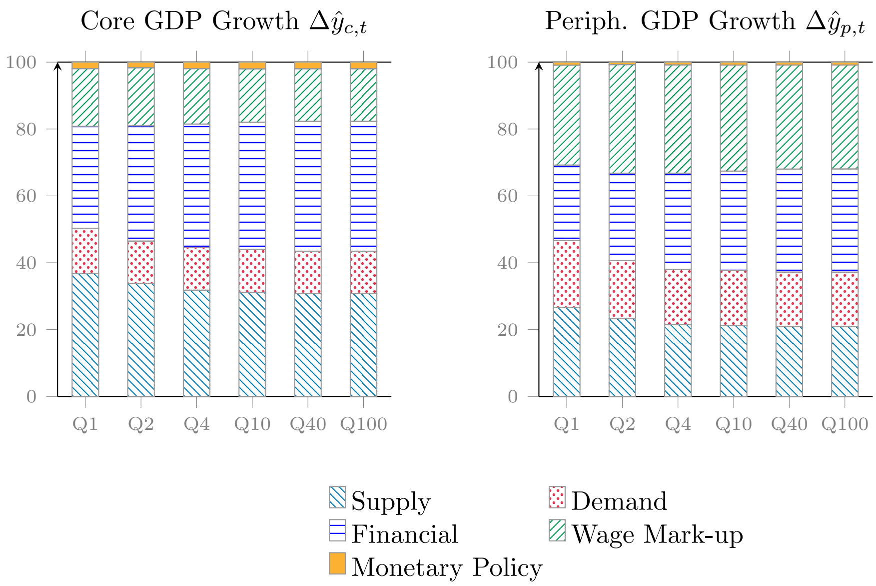


FIGURE C.2: Forecast error variance decomposition of GDP growth at the mean of the posterior distribution generated by the model in Chapter 4.

3 Robustness Check to the Zero Lower Bound

In the quantitative simulations of Chapter 3 and Chapter 5, we performed monetary policy coefficients optimization exercises without considering the perspective of hitting the zero lower bound (ZLB). In DSGE models, the zero lower bound has initially been addressed by McCallum (2000) and Woodford (2002). In our simulations, we optimize the policy coefficient on inflation using a welfare criterion in Chapter 5, given our grid search $\phi^{\pi} \in [1, 3]$ we found that the optimal parameter that penalizes inflation is $\phi^{\pi} = 3$, which is higher than the estimated coefficient. A high value of ϕ^{π} increases the volatility of the nominal interest rate and, in turn, increases the probability of violating the zero lower bound.

In this section, we check whether the model conclusions rely on realistic scenarios by computing the ZLB probability. To do so, we first consider the estimated model in Chapter 5 and generate artificial series for the Euro area given the estimated standard deviations of shocks. As example, in Figure C.3, we generate 110 draws of the ECB nominal interest rate and we neglect the first 10 draws. As observed, with high value of ϕ^{π}, the probability to violate the zero lower bound increases as the interest rate approaches zero. For the estimated and the optimized scenarios, the interest rates remain far from zero.

To get the probability of hitting the zero lower bound using the model asymptotic properties, we generate a larger sample of 1,000 draws and we compute the number of times the interest rate is below 0. To compute a confidence interval, we reiterate the operation 100 times. Finally, we do this exercise for various values of ϕ^{π}.

Figure C.4 reports the results. We find that on policy coefficients lying in the interval $(1, 3]$ for ϕ^{π} is relevant as the ZLB is clearly below 2%, which is faily low. Considering a larger grid search interval could lead to fallacious results. For instance, Quint & Rabanal (2013) explore monetary policy coefficients in the interval $(1, 5]$ without computing the zero lower bound probability, this could lead to fallacious results in terms of welfare ranking of alternative implementation schemes. In the same vein, Darracq-Pariès et al. (2011) consider wider intervals for monetary policy coefficients than Quint & Rabanal (2013) and they probably face a ZLB probability higher than 20% in their quantitative simulations.

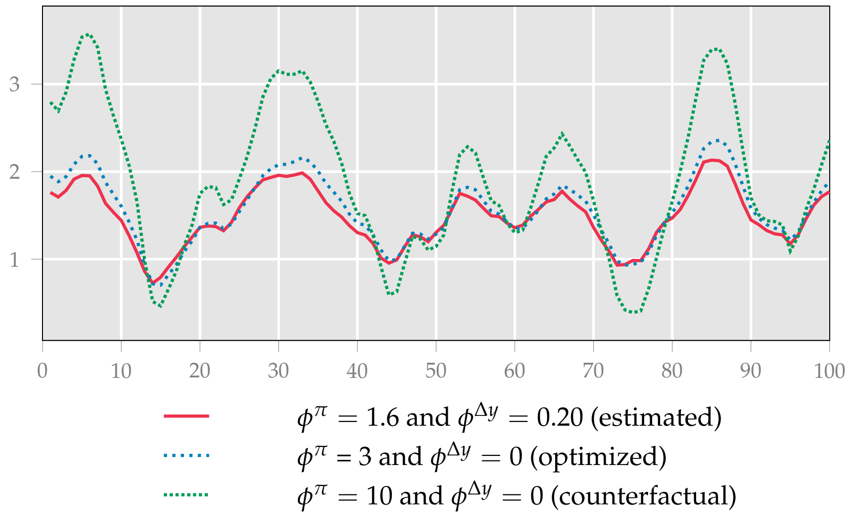


FIGURE C.3: ECB nominal interest rate simulated by the model of Chapter 5.

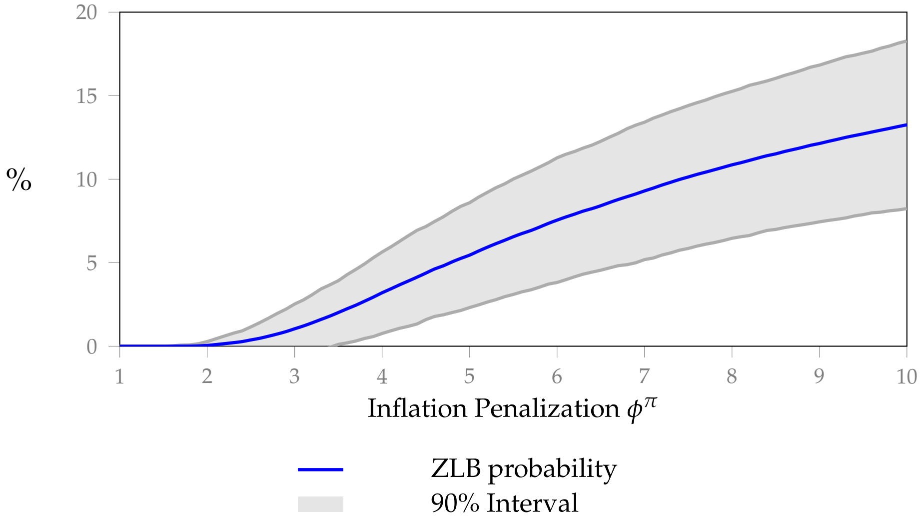


FIGURE C.4: Zero lower bound probability for various values of the monetary policy reaction parameter to inflation generated by the model of Chapter 5.

4 Historical Decomposition of Business and Credit Cycles in the UEM

In Figure C.5 and Figure C.6, we perform an historical decomposition of the dynamics of the four main variables of interest (activity, inflation, corporate and interbank loan supplies) as in Smets & Wouters (2007). The aim of the exercise is to investigate the consequences of the financial crisis of 2007 on the driving forces of activity, investment and corporate and interbank loan supplies. We plot the same figure as Smets & Wouters (2007): we gather the shocks in five groups: supply (productivity), demand (investment costs, spending and preferences), financial (deposit and credit rates mark-ups, collateral crunch, bank liabilities crunch), monetary policy and mark-ups (inflation and real wages).

In Figure C.5, we observe that the financial crisis episode was triggered by a demand shock followed by persistent financial shocks for core countries. The story is different for peripheral countries as the financial turmoil started with large and persistent financial shocks. The model also catches up the fiscal consolidation period after 2011 via a slowdown in the positive contribution of demand shocks. Financial shocks have a significant impact on inflation fluctuations in core countries inflation fluctuations. In this environment, monetary and macroprudential policies can play a major role in dampening such macroeoconomic developments. Turning to peripheral countries, we get the same kind of result during the post crisis period: the deflation that hits peripheral countries is explained by the model by depressed and persistent financial cycles.

Figure C.6 reports financial cycles (corporate and interbank loan supplies in the two regions). Remarkably, corporate loan cycles are mainly driven by financial shocks. We observe that the the financial crisis episode was triggered by a demand shock followed by persistent financial shocks for core countries. Volatility is much higher for peripheral countries. Postcrisis developments a clearly impacted by the curative measures undertaken in this area. The picture for interbank loans is a bit different, as demand shocks play an important role in the observed fluctuations of this varible in both parts of the Eurozone. This feature can be link to the household preference shock that increases saving, and conversely, the size of deposit in the banking system. As banks are capital constrained, the balance sheet of this agent plays an important role on macroeocnomic developments. One interesting feature observed is that the US subprime crisis depressed interbank supply one year before the beginning of Eurozone economic slump. This kind of result underlines the interest of focussing the interbank loan developements as an early warning signal of a forthcoming crisis event.

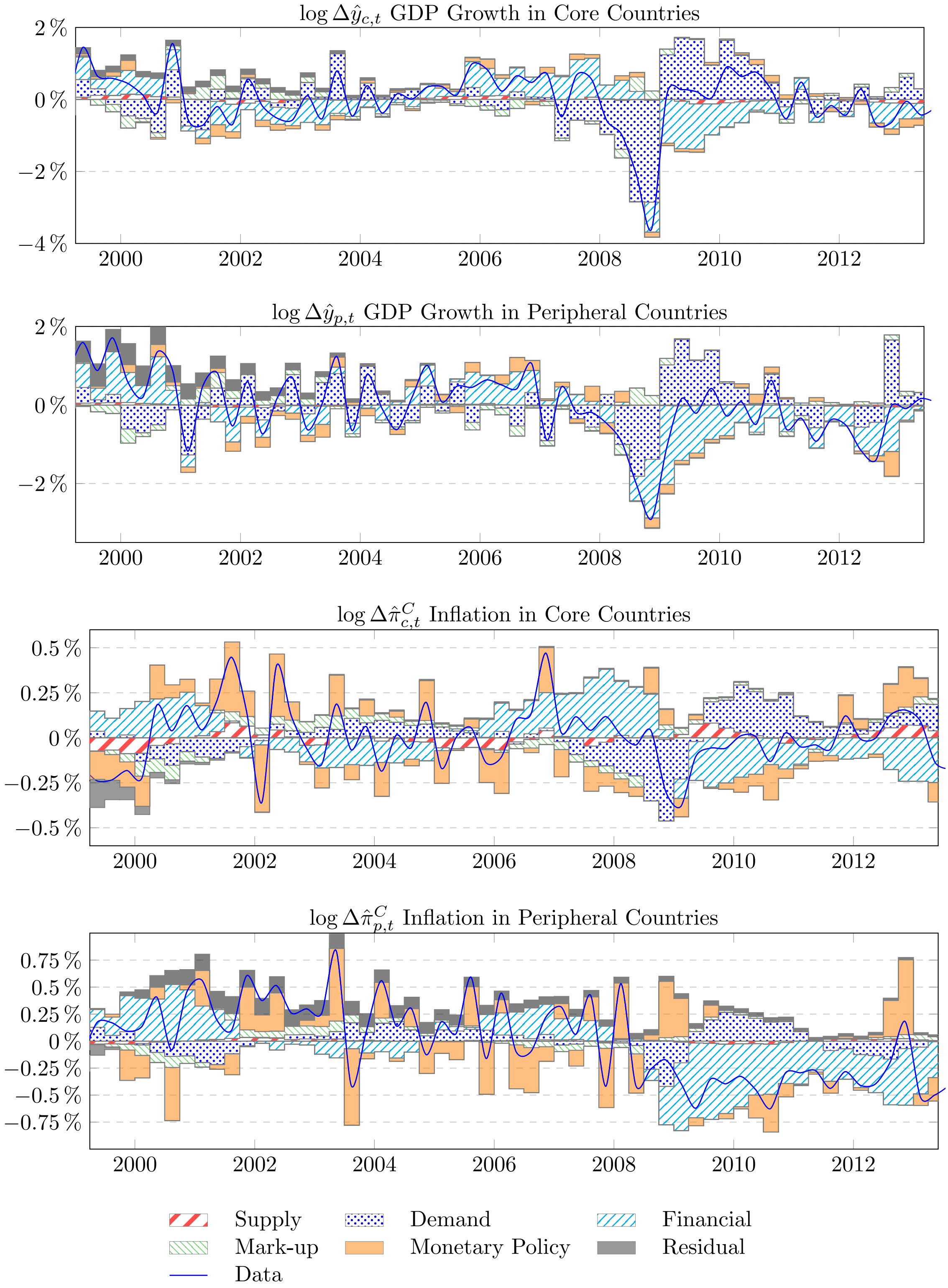


FIGURE C.5: The historical decomposition of output and inflation generated by the model in Chapter 5.

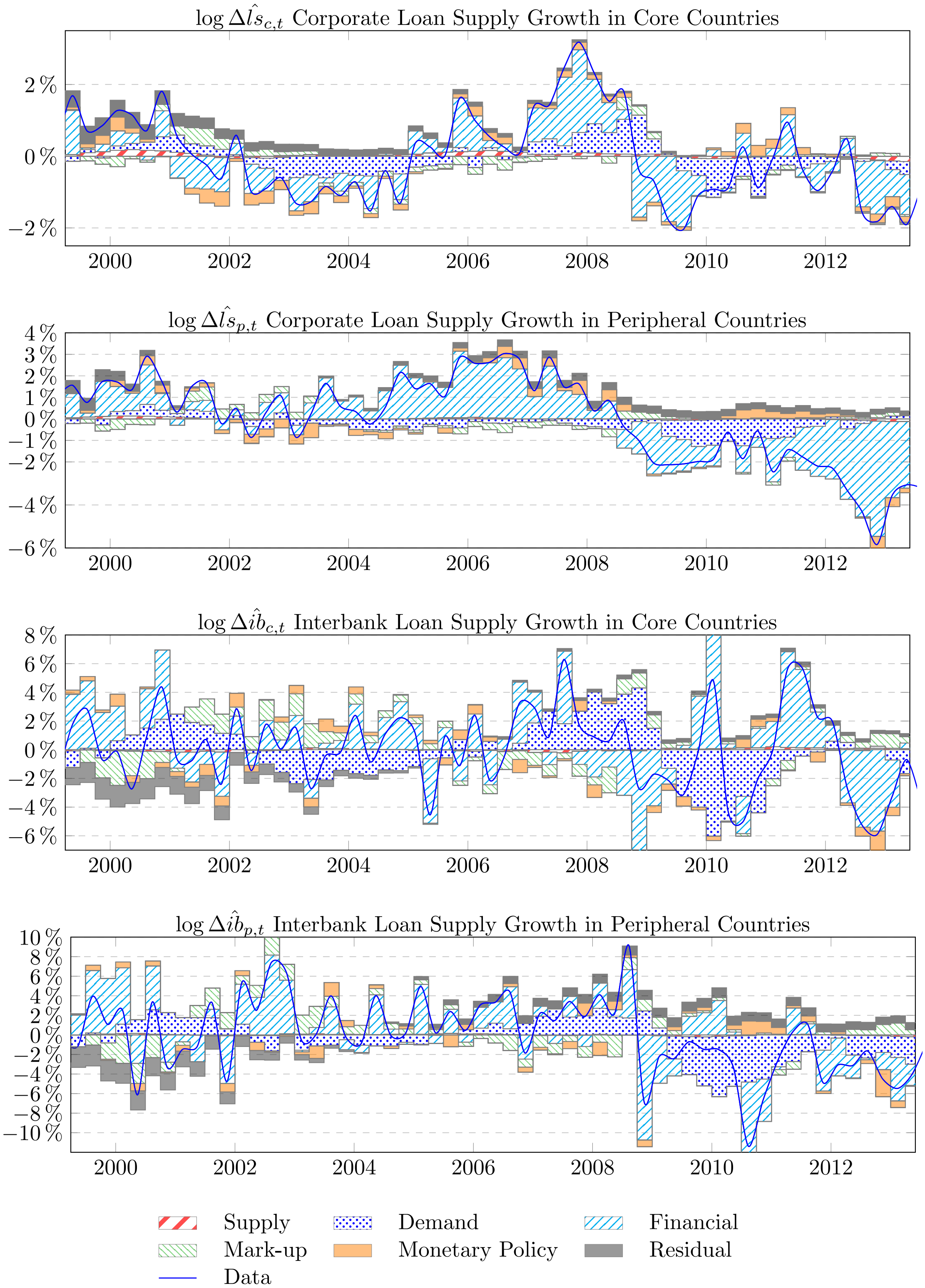


FIGURE C.6: The historical decomposition of corporate and interbank credit supply generated by the model in Chapter 5.

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Essais sur l'intégration bancaire et la politique macroprudentielle

L'objectif de cette thèse est d'évaluer la conduite des politiques macroprudentielles dans une union monétaire hétérogène, comme la zone euro, en s'appuyant sur les très récents développements théoriques et empiriques des modèles en équilibre général dynamique stochastique (DSGE) et de l'économétrie Bayésienne. Dans notre analyse, nous considérons deux faits majeurs caractérisant l'Eurosystème: la divergence des cycles économiques entre le coeur et la périphérie de la zone et l'intégration bancaire à l'origine de spillovers lors de la mise en oeuvre de politiques macroprudentielles. Voici les résultats que nous tirons de nos expérimentations. D'abord, la mise en oeuvre des mesures de politique macroprudentielle améliore le bien-être au niveau de l'union. Les gains de bien-être plus élevés sont observés lorsque les pays utilisent plusieurs instruments et lorsque la politique macroprudentielle est mise en oeuvre de manière granulaire. Cependant, la conduite de la politique macroprudentielle n'est pas forcément bénéfique pour tous les pays participants: dans la plupart des cas, les pays périphériques sont gagnants tandis que les pays du coeur enregistrent des faibles gains de bien-être voire parfois des pertes. Dans nos simulations, nous constatons qu'il existe un équilibre favorisant le bien-être à la fois aux niveaux mondial et national pour tous les participants mais sa réalisation nécessite une intervention d'une autorité fédérale telle l'ESRB. Enfin, l'introduction de prêts transfrontaliers ouvre un nouveau canal de transmission international important qui tend à augmenter les gains de bien-être associées à des mesures macroprudentielles. Ignorer ces prêts bancaires transfrontaliers peut conduire à des résultats fallacieux dans le classement des différents plans d'instauration de la politique macroprudentielle.
Mots clés : Macroéconomie; Zone Euro; Cycles d'Affaires; Modèles DSGE; Économtrie Bayésienne; Politique Macroprudentielle; Politique Monétaire; Finance Internationale.

Essays on cross-border banking and macroprudential policy

The aim of this thesis is to evaluate the conduct of macroprudential policies in an heterogenous monetary union, such as the Eurozone, by borrowing on the very recent theoretical and empirical developments of Dynamic Stochastic General Equilibrium (DSGE) models and Bayesian econometrics. We account for two main patterns of the Eurosystem: the business cycles divergence between core and peripheral countries and the globalization of banking and its spillovers when implementing macroprudential policies. As a main result, the implementation of macroprudential policy measures improves welfare at the global level. The highest welfare gains are observed when countries use multiple instruments and when macroprudential policy is implemented in a granular fashion. However, the conduct of macroprudential policy is not a free lunch for participating countries: in most situations, peripheral countries are winners while core countries record either smaller welfare gains or even welfare losses. In many policy experiments, we find that there exists an equilibrium that combines welfare increases at both the global and national levels for all participants but its enforceability requires a federal action, thus justifying the existence of a coordination mechanism such as the ESRB in the Eurozone. Finally, the possibility of banks to engage in cross border lending introduces an important spillover channel that tends to increase the welfare gains associated to macroprudential measures. Ignoring this phenomenon may lead to fallacious results in terms of the welfare ranking of alternative implementation schemes.

Keywords : Macroeconomics; Eurozone; Business Cycles; DSGE models; Bayesian Econometrics; Macroprudential Policy; Monetary Policy; Cross-border Banking.